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THE

CHRISTIAN PHILOSOPHER;

A

COLLECTION OF THE BEST DISCOVERIES IN NATURE,

WITH

RELIGIOUS IMPROVEMENTS.

BY COTTON MATHER, D.D. F.R.S.

THE STYLE MADE EASY AND FAMILIAR.

CHARLESTOWN:

PUBLISHED AT THE MIDDLESEX BOOKSTORE.

J. M'Kown, Printer.

1815.

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1815

District of Massachusetts, to wit:

District Clerk's Office.

[L.S.] Be it remembered, That on the fourth day of August, A. D. 1815, and in the fortieth year of the independence of the United States of America, William Collier of the said district has deposited in this office the title of a book, the right whereof he claims as proprietor, in the words following, to wit:—"The Christian Philosopher; a collection of the best discoveries in nature, with religious improvements. By Cotton Mather, D. D. F. R. S. The style made easy and familiar." In conformity to the act of the Congress of the United States, entitled, "an act for the encouragement of learning, by securing the copies of maps, charts, and books to the authors and proprietors of such copies, during the times therein mentioned;" and also to an act entitled, "an act supplementary to an act, entitled, an act for the encouragement of learning, by securing the copies of maps, charts, and books, to the authors and proprietors of such copies during the times therein mentioned; and extending the benefits thereof to the arts of designing, engraving, and etching historical and other prints."

WM. S. SHAW, { Clerk of the District of Massachusetts.

DEDICATION.

TO MR. THOMAS HOLLIS,

MERCHANT IN LONDON.

SIR, the learned author of the ensuing treatise, has already diffused his name and reputation in a great variety of useful works; by which the better part of mankind do sufficiently know him to be in labours more abundant. The reader will find in this treatise, a collection from writers of the first and best character, both in our own and other nations; and every observation improved to the ends of devotion and practice. The remarks that the author gives, are so mingled with the discoveries that he has brought together, that as it shows us with what spirit he has pursued his inquiries into the wonders of the universe, so it is both an instruction and a pattern to a serious mind. He has generally drawn into his application, all that the Bible saith upon the several subjects: and thus he lays open the two great books of God, nature and Scripture. In this way, our curiosity is not only entertained, but sanctified; the invisible things of God from the creation of the world are seen, and improved to the glory of Him whose they are.

Your surprising generosity to the Academy in New England, has made this dedication more proper to you than any other person. Such a beneficence is an argument how thoroughly you desire that the doctrines of the Gospel, and the purity of discipline, may be transmitted to future generations. And certainly, it is the noblest, and the most divine application of your charity, when by it you are a fellow-helper to the truth. This is given to those from whom you can have no expectation of recompense; but as it is all done to the Lord, and not to men, so by him it will be remembered at the resurrection of the just. You know how much it is against my temper to give flattering words, and I am convinced that it is against yours to receive them. But I have reason to think, that the reverend Author, and the whole country where God has placed him, will believe this dedication well directed, to the best of all their benefactors. This administration of service is abundant, by many thanksgivings to God, (whilst by this ministration, they glorify God for your professed subjection to the Gospel of Christ, and for your liberal distribution to them and to all men) and by their prayer for you.

I have no more to add, but the apostle's wish, that your faith may grow exceedingly, and your charity daily abound; that whatever you do, may be done faithfully to the brethren, and to strangers.

I am, Sir, your sincere friend, and obedient servant,

THO. BRADBURY.

LONDON, Sept. 22, 1720.

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THE

INTRODUCTION.

THE essays now before us will demonstrate, that philosophy is no enemy, but a very great incentive to religion; and they will exhibit that philosophical religion, which will carry with it a most sensible character, and victorious evidence of a reasonable service. "Glory to God in the highest, and good-will towards men," animated and exercised; and a spirit of devotion and of charity inflamed, in such methods as are offered in these essays, cannot but be attended with more benefits, than any pen describe or mind conceive.

In the dispositions and resolutions of piety thus enkindled, man, with unutterable satisfaction answers the grand end of his being, which is, to glorify God. He discharges also the office of a priest for the creation, under the influences of an admirable Saviour, and therein asserts and assures his title to that priesthood, to which the blessedness of the future state will very much consist in being advanced. The whole world is indeed a temple of God, built and fitted by that Almighty architect; and in this temple, every one, affecting himself with the occasions for it, will speak of his glory. He will also rise into that superior way of *thinking* and of living, which the wisest of men will choose to take; with which the more polite part of mankind, and the honourable of the earth, will esteem it no dishonour for them to be acquainted. Upon that passage occurring in the best of books, "Ye sons of the mighty, ascribe

to the Lord glory and strength; it is a gloss and a hint of Munster, which carries with it a cogency; there is nothing so great and so magnificent, which does not subserve the praise and glory of God, its Creator. Behold, a religion, which will be found without controversy; a religion, which will challenge all possible regards from the high, as well as the low, among the people; I will resume the term, a philosophical religion, and yet how evangelical!

In prosecuting this intention, and in introducing almost every article of it, the reader will continually find some author or other quoted. This constant method of quoting, it is to be hoped, will not be censured, as proceeding from an ambition to make a show of learning; and that Austin's reproach of Julian may not be applied to it. "Who is there, that reads, or hears your works, and is not terrified at the sound of the great names, it contains? should he be unlearned as many are, would he not suppose you a prodigy, to understand them yourself?" Nor will there be discernible any spice of the impertinent vanity, which La Bruyere hath so well satirized: "Herillus will always cite, whether he speaks or writes. He makes the prince of philosophers to say, that wine inebriates; and the Roman orator, that water temperates it. If he talks of morality, it is not he, but the divine Plato, who affirms, that virtue is amiable, and vice odious. The most common and trivial things, which he himself is able to think of, are ascribed by him to Latin and Greek authors." But in these quotations, there has been proposed, first, a due gratitude to those, who have been my instructers; and indeed, something

within me would have led me to it, if Pliny, who is one of them, had not given me a rule; "It is ingenuous to confess our benefactors." It appears also but a piece of justice, that the names of those whom the great God has distinguished, by employing them to make those discoveries, which are here collected, should live and shine in every such collection. Among these, let it be known, that there are especially two, to whom I have been more indebted, than to many others; the industrious Mr. Ray, and the inquisitive Mr. Derham, upon whom, in divers paragraphs of this rhapsody, I have had very much of my subsistence, and I give thanks to Heaven for them.

It is true, some scores of other philosophers have been consulted on this occasion; but an industry so applied, has in it very little to bespeak any praises for him that has used it; he earnestly renounces them, and solicits, that not only he, but the greater men, who have been his teachers, may disappear before the glorious God, whom these essays are all written to represent as worthy to be praised, and by whose grace we are what we are; nor have we any thing but what we have received from him.

A considerable body of men (if the Jansenists may now be thought so) in France, have learnt of Mr. Pascal, to denote themselves by the French impersonal particle *on;* and it was his opinion, that an honest man should not be fond of naming himself, or of using the word I, and me; that christian piety will annihilate our I, and me, and human civility will suppress it, and conceal it.

Most certainly there can be very little pretence to an I, or me, for what is done in these essays.

It is done, and entirely, by the help of God: this is all that can be pretended to.

There is very little, that may be said, really to be performed by the hand that is now writing; but only the devotional part of these essays, though they are not altogether destitute of American communications: and if the virtuosos, and all the genuine philosophers of our age, have approved the design of the devout Ray and Derham, and others, in their treatises; it cannot be distasteful to them, to see what was more generally hinted at by those excellent persons, here more particularly carried on, and the more special flights of the true philosophical religion exemplified. Nor will they that value the essays of the memorable ancients, Theodoret, Nazianzen, and Ambrose, upon the works of the Six Days, count it a fault, if among lesser men in our days, there be found those who say, let me run after them. I remember, when we read, "praise is comely for the upright," it is urged by Kimchi, that the word which we render comely, signifies desirable, and acceptable; and the sense of that sentence is, that the righteous desire nothing more than the praise and glory of God. Sure I am, such essays as these, to observe, and proclaim, and publish the praises of the glorious God, will be desirable and acceptable to all that have a right spirit in them; the rest, who are blinded, are fools and as little to be regarded as a monkey flourishing a broomstick! The worst, that can be wished them, is that they may reap the fruits of their own folly. For such centaurs to be found in the tents of professed christianity!—good God, unto what times hast thou reserved us! If the self-taught philosopher

will not, yet Abubeker, a Mahometan writer, by whom such an one was exhibited more than five hundred years ago, will "rise up in the judgment with this generation, and condemn it." Reader, even a Mahometan will shew thee one, without any teacher, but reason in a serious view of nature, led on to the acknowledgment of a glorious God. Of a man, supposed as but using his rational faculties in viewing the works of God, even the Mahometan will tell thee; "There appeared unto him those footsteps of wisdom and wonders in the works of creation, which affected his mind with an excessive admiration; and he became hereby assured, that all these things must proceed from such a voluntary agent as was infinitely perfect, yea, above all perfection; such an one to whom the weight of the least atom was not unknown, whether in heaven or earth. Upon his viewing of the creatures, whatever excellency he found of any kind, he concluded, it must needs proceed from the influence of that voluntary agent, so illustriously glorious, the Fountain of being, and of working. He knew therefore, that whatever excellencies were by nature in him, were by so much the greater, the more perfect, and the more lasting; and that there was no proportion between those excellencies which were in Him, and those which were found in the creatures. He discerned also, by the virtue of that more noble part of his, whereby he knew the necessarily existent Being, that there was in him a certain resemblance thereof: and he saw, that it was his duty to labour by all manner of means, how he might obtain the properties of that Being, put on his qualities, and imitate his actions; to be diligent and careful also

in promoting his will; to commit all his affairs unto him, and heartily to acquiesce in all those decrees of his which concerned him, either from within, or from without: so that he pleased himself in Him, though he should afflict him, and even destroy him." I was going to say, O, the precious words of a golden mind! But the great Alsted instructs me, that we Christians, in our valuable citations from them that are strangers to Christianity, should seize upon the sentences as containing our truths, detained in the hands of unjust possessors; and he allows me to say, hear Cicero, whom nature taught. However, this I may say, God has thus far taught a Mahometan! And this I will say, Christian, beware lest a Mahometan be called in for thy condemnation!

Let us conclude with a remark of Minutius Fælix: "If so much wisdom and penetration be requisite to observe the wonderful order and design in the structure of the world, how much more were necessary to form it!" If men so much admire philosophers, because they discover a small part of the wisdom that made all things; they must be totally blind, who do not admire that Wisdom itself!

THE

CHRISTIAN PHILOSOPHER.

Remember that thou magnify His work, which men behold.
JOB XXXVI, 24.

THE works of the glorious God in the creation of the world, are what I now propose to exhibit; in brief essays to enumerate some of them, that he may be glorified in them; and indeed my essays may pretend to no more than some of them; for, Theophilus, writing of the creation, to his friend Antolycus, might very justly say, that if he should have a thousand tongues, and live a thousand years, yet he were not able to describe the admirable order of the creation, such a transcendent greatness of God, and the riches of his wisdom appearing in it!

Chrysostom, I remember, mentions a twofold book of God; the book of the creatures, and the book of the Scriptures: God having taught us first of all by his works, did it afterwards by his words. We will now for a while read the former of these books, it will help us in reading the latter: they will admirably assist one another. The philosopher being asked, what his books were; answered, the books of nature. All men are accommodated with that public library. Reader, walk with me into it, and see what we shall find so legible there, "that he that runs may read it." Behold, a book, whereof we may agreeably enough use the words of honest Ægardus; "This book may be read by all, although they may never have learned to read; it is accessible to all; it is *exposed to the eyes* of all."

ESSAY I.—*Of* LIGHT.

WOULD it not be proper, in the first place, to lay down those laws of nature, by which the material world is governed, and which, when we come to consider, we have in the rank of second causes, no further to go? All mechanical accounts are at an end; we step into the glorious God immediately: the very next thing we have to do, is to acknowledge Him, who is the first cause of all: and the Christian philosopher will on all invitations make the acknowledgments. The acute pen of Dr. Cheyne has thus delivered them.

I. All bodies persevere in the same state of rest, or of moving forwards in a straight line, unless forced out of that state, by some violence outwardly impressed upon them.

II. The changes made in the motions of bodies, are always proportional to the impressed force that moves them; and are produced in the same direction with that of the moving force.

III. The same force with which one body strikes another, is returned upon the first by that other; but these forces are impressed by contrary directions.

IV. Every part of every body attracts or gravitates towards every part of every other body: but the force by which one part attracts another, in different distances from it, is reciprocally as the squares of those distances; and at the same distance, the force of the attraction or gravitation of one part towards divers others, is as the quantity of matter they contain.

These are laws of the great God, who formed all things. God is ever to be seen in these everlasting ordinances. But now, in proceeding to

magnify that work of God which men behold, it seems proper to begin with that by which we behold the rest.

The light calls first for our contemplation. A most marvellous creature, whereof the great God is the father: by that alone we might discover the being of a God.

The verus Christianismus of the pious John Arndt very well does insist upon that strain of piety; God and his love exhibited in the light.

It was demanded, In what place is the light contained? By what way is the light divided?

Aristotle's definition, "Light is in the inworking of a diaphanous body," is worth an attentive consideration.

Light is undoubtedly produced, as Dr. Hook judges, by a motion, quick and vibrative.

It is proved by Mr. Molyneux, that light is a body. Its refraction, in passing through a diaphanous body, shews that it finds a different *resistance*; resistance must proceed from a contact of two bodies. Moreover, it requires time to pass from one place to another, though it has indeed the quickest of all motions. Finally, it cannot by any means be increased or diminished. If you increase it, it is by robbing it of some other part of the medium which it would have occupied, or by bringing the light, that should naturally have been diffused through some other place, into that which is now more enlightened.

Sir Isaac Newton judges, it is probable, that bodies and light act mutually on one another. Bodies upon light, in emitting it, and reflecting it, and refracting it, and inflecting it: light upon bodies, by heating them, and putting their parts into a vi*brating motion*.

All hypotheses of light are too dark, which try to explain the phenomena by new modifications of rays; they depend not on any such modifications, but on some congenite and unchangeable properties, essentially inherent in the rays.

The rays of light are certainly little particles, actually emitted from the lucent body, and refracted by some attraction, by which light, and the bodies on which it falls, do mutually act upon one another. It is evident, that as rays pass by the edges of bodies, they are incurvated by the action of these bodies, as they pass by them.

And it is now perceived, that bodies draw light, and this light puts bodies into heat: and that the motion of light is therefore swifter in bodies, than in vacuo, because of this attraction; and slower after its being reflected, than in its incidence.

Irradiated by the discoveries of the great Sir Isaac Newton, we now understand, that every ray of light is endowed with its own colour, and its different degree of refrangibility and reflexibility. One ray is violet, another indigo, a third blue, a fourth green, a fifth yellow, a sixth orange, and the last red. All these are original colours, and from the mixture of these, all the intermediate ones proceed; and white from an equable mixture of the whole: black, on the contrary, from the small quantity of any of them reflected, or all of them in a great measure suffocated. It is not bodies that are coloured, but the light that falls upon them; and their colours arise from the aptitude in them, to reflect rays of of one colour, and to transmit all those of another. It is now decided, *no colour in the dark!*

Though light be certainly a body, it is almost impossible to conceive how small the corpuscles of

it are. Dr. Cheyne illustrates it with an experiment, that it may be propagated from innumerable different luminous bodies, without any considerable opposition to one another. Their several streams of light will be together transmitted into a dark place, through the least orifice in the world. Suppose a plate of metal, having at the top the smallest hole that can be made, were erected perpendicularly upon an horizontal plane, and about it were set numberless luminous objects of about the same height with the plate, at an ordinary distance from it; the light proceeding from every one of these objects, will be propagated through this hole, without interfering.

Mr. Romer, from his accurate observations of the eclipses on the Satellites of Jupiter, their immersions and emersions, thinks he has demonstrated, that light requires one second of time to move 9000 miles. He shews, that the rays of light require ten minutes of time to pass from the sun to us. And yet Mr. Hugens hath shewn, that a bullet from a cannon, without abating its first velocity, would be 25 years passing from us to the sun. So that the motion of light is above a million times swifter than that of a cannon ball; yea, we may carry the matter further.

We suppose the distance of the sun from the earth to be 12000 diameters of the earth, or suppose 10000, the light then runs 1000 diameters in a minute; which is at least 130,000 miles in a second. Dr. Cheyne shews, that light is about 600,000 times more swift than sound. Amazing velocity!

To checker the surprise at so swift a motion, I may propound one that shall be as very surpris-

ingly slow. Dee affirms, that he and Cardan together saw an instrument, in which there was one wheel constantly moving with the rest, and yet would not finish its revolution under the space of 7000 years. It is easy to conceive with Stevinus, an engine with 12 wheels, and the handle of such an engine to be turned about 4000 times in an hour, (which is as often as a man's pulse beats) yet in 10 years time the weight at the bottom would not move near so much as an hair's breadth: and as Mersennus notes, it would not pass an inch in 1,000,000 years; although it be all this while in motion, and have not stood still one moment: for it is a mistake of Cardan, that very slow motions of necessity suppose intermediate rest.

"Behold the light emitted from the sun;
What more familiar, and what more unknown?
While by its spreading radiance it reveals
All nature's face, it still itself conceals.
See how each morn it does its beams display,
And on its golden wings brings back the day!
How soon th' effulgent emanations fly
Through the blue gulf of interposing sky!
How soon their lustre all the region fills,
Smiles on the vallies, and adorns the hills!
Millions of miles, so rapid is their race,
To cheer the earth, they in few moments pass.
Amazing progress! At its utmost stretch,
What human mind can this swift motion reach?
But if, to save so quick a flight, you say,
The ever-rolling orb's impulsive ray
On the next threads and filaments does bear,
Which form the springy texture of the air,
That those still strike the next, till to the sight
The quick vibration propagates the light:
Still 'tis as hard, if we this scheme believe,
The cause of light's swift progress to conceive."

The Jews have a good saying, The works of the external creation, possess the image of internal.

It will well enough become a Christian philosopher, to allow for that image in his contemplations, and with devout thoughts now and then reflect upon it.

Before I go any further, I confess myself unable to resist the invitation, which, I think, that I have, to insert an observation of Hugo de Sancto Victore; That every creature addresses a treble voice unto us: accept the benefit; be grateful; escape punishment; indeed, there is no speech nor language where their voice is not heard. It is an exercise highly becoming the Christian philosopher, to fetch lessons of piety from the whole creation of God, and hear what maxims of piety all the creatures would, in the way of reflection and similitude, mind us of. In the prosecution of these Meleteticks, what better can be considered, than this treble voice, from all these thousands of powerful preachers, whom we have continually surrounding us? First, accept the benefit; consider, what is the benefit which a good God has, in this creature, bestowed upon me? Secondly, be grateful; consider what is the service which I owe to a gracious God, in the enjoyment of such a creature? Lastly, escape punishment; consider, what is the sorrow which a righteous God may inflict upon me by such a creature, if I persist in disobedience to Him? Even a pagan Plutarch will put the Christian philosopher in mind of this, that the world is no other than the temple of God; and all the creatures are the glasses, in which we may see the skill of Him that is the maker of all. And his brother Cicero has minded us, we know God by his works. It is no wonder then that a Bernard

should see this; a real lover of God, wherever he turns himself, has the friendly admonitions of his Creator. The famous Hermite's book, of these three leaves, the Heaven, the Water, and the Earth, well studied, how nobly would it fill the chambers of the soul with the most precious and pleasant riches? Clemens of Alexandria calls the world, a scripture of those three leaves; and the creatures therein speaking to us, have been justly called true preachers, by those who have best understood them: When we contemplate the obvious wonders, and beauties of the world, and survey the operations of prolific nature, we are forced to acknowledge, that the Divine power is manifest in every part; and that even the smallest spire of grass furnishes abundant proof of the existence of a God. But the light now calls for me.

How glorious a body! "But how infinitely, and beyond all comprehension glorious then, the infinite God, who has challenged it as His glory! Isa. xlv, 7. I form the light. The God of whom we have that sublime stroke, in the history of the creation; he said, Let there be light, and there was light! The God whose majesty is within that holy of holies, where He dwells in the light, that no man can approach unto! Lord, thou hast in a wondrous display of thy benignity, afforded the benefit of the light unto thy creatures: Whatever does make manifest, is light. How miserable should we be, and in what inexpressible confusion, if the light were withheld from us! What could be manifest to us; what enjoyed or performed by us! O let all that walk in the light of the living, unite in praises to the Creator of the light! O! give thanks to the Lord, for He is

good, and his mercy endureth for ever. But Lord, wilt thou leave my soul in darkness! The light granted unto the soul, in the knowledge of those things, which to know is life eternal, is more precious and needful, than that in which our body finds itself so much befriended. O Father of glory, let me have the eyes of my understanding enlightened.

"I have a most glorious Redeemer, of whom I am assured, that he is the true light, and the light of the world. A light which, like other light, carries its own evidence with it: there needs no more to prove, that our blessed Jesus is the Son of God, and the Saviour of the world, than attentively to behold Him. He can be no other, than what he asserts himself to be, the light of men. Lord, in thy light I shall see light. When I see the truth as it is in Jesus, in such a revelation and such an exhibition, as my Jesus gives of it, then I see every thing in a true *light*. My Saviour, thou art more precious, and more needful, and more useful to me than the *light*. I will walk in thee, and under thy conduct; so shall I walk in the light continually.

"But what signifies the light, unto him that has no eyes to perceive it. O my Redeemer! bestow thou an eye upon me: a faculty to discern the things that are spiritually discerned.

"For the light of reason, which enlightens every man that comes into the world; every man has all possible reason to glorify God, and never do any thing, whereof any man may justly say, It seems to me unreasonable.

"But, O my God, thou hast favoured us with a rich conglobation of light, in the book of thy

lively oracles, wherein we have a light shining in a dark place. I would consider every thing in the light wherein this lovely book sets it before me: But, let me not rebel against the light.

"The light is truly sweet. But, what shall I find the inheritance of the saints in light! They that are shut out of that light, and cast into outer darkness, and where they shall never see light; Oh! the weeping and wailing, and gnashing of teeth, to which they must be exposed! My Saviour, I am under thy conduct, passing through a gloomy valley into thy light; and when I sit in darkness, the Lord will be a light unto me.

"How swift the motion of the light! But, O my Saviour, why no more swift in thy coming to visit and relieve a world lying in the perpetual night of wickedness? Why thy chariot so long in coming?

"And, O my soul, why art thou slow in thy contemplations of God, and Christ, and heaven; fly thou thither, with a swiftness beyond that of the light, (for so thou canst), upon all occasions."

ESSAY II.—*Of the* STARS.

LET us proceed, and conforming to the end of our erect stature, behold the heavens, and lift up our eyes unto the stars.

The learned Hugens has a suspicion, that every star may be a sun to other worlds in their several vortices. Consider then the vast extent of our solar vortex, and into what astonishments must we find the grandeur and glory of the Creator to grow upon us! Especially if it should be so, (as he thinks) that all these worlds have their inhabitants, whose praises are offered up to our God!

With such a view of the heavenly bodies, how little must the earth appear! His improvement of the thought is, How little of this little has vain man to strive for, and to boast of! O the folly of vain desires!

Mr. Childrey mentions two curiosities, which ought to be a little further inquired into. The one is, that between the two constellations of Cygnus and Cepheus, there lies cross the milky-way, a black, long, little cloud, neither increasing, nor changing the place in which it makes its appearance.

The other is, that in February, and a little before and after that month, in the evening, when the twilight has near deserted the horizon, there is a very distinguishing way of the twilight; a bright path striking up towards the pleiades, and almost reaching them, which is not observed any other time of the year.

The Jews have a fancy among them, that when the Almighty first bespangled the heavens with stars, he left a spot near the north pole unfinished and unfurnished, that so if any other should set up for a God, there might be this trial made of his pretensions; go, fill up, if you can, that part of the heavens, which is yet left imperfect. But without any such suppositions, we may see enough in the heavens to proclaim this to us; lift up your eyes on high, and behold: Who has created these things? None but an infinitely glorious God could be the creator of them!

The telescope, invented the beginning of the last century, and improved now to the dimensions even of eighty feet, whereby objects of a mighty distance are brought much nearer to us, is an

instrument wherewith our good God has in a singular manner favoured and enriched us: a messenger that has brought unto us, from very distant regions, most wonderful discoveries.

My God, I cannot look upon our glasses without uttering thy praises: by them I see thy goodness to the children of men!

By this enlightener of our world, it is particularly discovered, That all the planets at least, excepting the Sun, are dense and dark bodies; and that what light these opaque bodies have, is borrowed from the Sun.

That every one of the planets, excepting the Sun, do change their faces like the Moon. Venus and Mercury appear sometimes like an half-moon, and sometimes quite round, according as they are more or less opposite to the Sun. Mars has his times of appearing in a curve-lined figure. Jupiter has four little stars, that continually move about him, and in doing so, cast a shadow upon him. Saturn has a ring encompassing him.

That each of these planets have spots in their superficies, like those of the Moon.

That not only each of these planets, but the Sun also, beside whatever other motion they may have, do move themselves upon their own centre; some of them with a motion of revolution, others by that of libration.

It was a good remark made by one of the ancients, What is heaven with the decorations of nature, but a kind of glass, which reflects the workmanship of the great Architect?

The pagan Tully, contemplating the admirable order, and the incredible constancy of the heavenly bodies and their motions, adds upon it:

whosoever thinks this is not governed by mind and understanding, is himself to be accounted void of all mind and understanding.

According to Mr. Hugens, the distance of the sun from us is 12,000 diameters of the earth. A diameter of the earth is 7,846 miles. The distance of the nearest fixed stars from us, compared with that of the sun, is as 27,664 to 1: So then the distance of the nearest fixed stars is at least 2,404,520,928,000 miles; which is so great, that if a cannon ball (going all the way with the same velocity it has when it parts from the mouth of the gun) would scarce arrive there in 700,000 years. Great God, what is thy immensity!

The number of the stars! The learned Arndt has a good thought upon it: If God has made such a multitude of stars, who can doubt, that he has by far a greater number of heavenly spirits, who are continually singing his praise.

"Glorious God, I give thanks to thee, for the benefits and improvements of the sciences, granted by thee unto these our latter ages. The glasses which our God has given us the discretion to invent, and apply for the most noble purposes, are favours of Heaven most thankfully to be acknowledged.

"The world has much longer enjoyed the Scriptures, which are glasses, that bring the best of Heavens much nearer to us. But though the object glasses are here, the eye glasses are wanting. My God, bestow thou that faith upon me, which, using the prospective of thy word, may discover the heavenly world, and acquaint me with what is in that world, to which I hope, I am going.

" I hear a great voice from the starry heaver ascribe ye greatness to our God. Great Gc what a variety of worlds hast thou created! Hc astonishing are the dimensions of them! Hc stupendous are the displays of thy greatness, a of thy glory, in the creatures, with which th hast replenished those worlds! Who can tell wl angelic inhabitants may there see and sing t praises of the Lord! Who can tell for what us those marvellous globes may be designed! (these unknown worlds I know thus much, it our great God that has made them all."

ESSAY III.—*Of the* FIXED STARS.

OUR great prospective having made inquii finds a far greater number of stars, than what can discern with the naked eye. The ancier reckoned only one thousand and twenty-two st in their fifty constellations. Kepler augments t number to one thousand three hundred and nine two. Bayer carries it on to one thousand sev hundred and nine. Travellers to the southwa increased the number of their constellations sixty-two. The number of the stars, broug down into our latest globes, is about ninete hundred; but those in the heavens are inconce ably more. Among the pleiades in a circle but one degree diameter, where our naked e sees but six, thus assisted we see forty-six.

The milky-way is nothing but an infinite nu ber of stars, which are so small, and lie so thic as to give but a confused glare unto us: and the nebulosœ, in the head of Orion.

The præsepe is a cluster of more than fo stars. Those adjacent unto the sword and gir

of Orion about forescore. Mr. Derham suspects, that the whiteness of the milky-way is not caused by the great number of the fixed stars in that place, but partly by their light, and partly by the reflection of their planets, which blend their light, and mix it.

It is a little surprising, that all the planets appear greater in the glass than to the naked eye; but the fixed stars appear smaller there.

The words of the ingenious Dr. Cheyne are worth considering: "Since our fixed stars are exactly of the same nature with our sun, it is very likely that they have their planets; and these planets have satellites; and these planets and satellites have inhabitants, rational and irrational; plants and vegetables, water and fire; analogous to those of our system." Ascribe ye greatness to our God!

That which renders it probable, that the fixed stars are bodies like our sun, is this: It is plain they shine by their own light. It is impossible they should appear so lucid as we see them, from the light of our sun transmitted upon them. It is their astonishing distance from us that causes the best of our telescopes to lessen them. Though we in this globe approach nearer to them, some 24,000 diameters of the earth, or 188,304,000 miles, one time of the year than another; yet their parallax is hardly sensible, or any at all: which could not be, if the distance were not wonderful.

Hence also, it is impossible they should be all in the surface of the same sphere, since our sun, which is one of them, cannot be reduced to this rule. They are doubtless at as immense

distances from one another, as the nearest of them is from us. Were we at such a distance from the sun, we should not have the least glimpse of the planets that now attend it. Their light would be too weak to affect us, and all their orbs would be united in that one lucid point of the sun.

There are discovered new stars in the firmament, which, having appeared a certain time, do again disappear.

A new star appeared about 125 years before the birth of our Saviour.

Claudian mentions one which appeared, A. C. 388. Albumazer Haly mentions one which appeared in the fifteenth degree of Scorpio, and continued four months.

In the year 1571, and the month of November, there appeared in that constellation, which we call the chair of Cassiopeia, a most notable and wonderful star of the first magnitude, which held a place among the other stars, not having any parallax, and kept a course like theirs: It continued fifteen months; then decreased; anon grew quite invisible. A noble person affirms, there was a black spot remaining in the place where that star appeared.

In the year 1601, there appeared a new star of the third magnitude, in the swan's breast, which continued visible twenty-five years, and then disappeared. Thirty-three years after, it appeared again in its former magnitude; but went away again in a year or two. It re-appeared five years after, and was extant for several years, but of no more than the sixth or seventh magnitude.

In the year 1671, another star which arrived to the third magnitude, appeared in the swan's bill;

it increases and then decreases, and is about a month making its revolution.

There is an admirable star in the whale's neck: This first appears as one of the sixth magnitude, and then increases by little and little, for one hundred and twenty days together, till it arrives to its full bigness and brightness, which is that of the third magnitude; wherein it continues fifteen days together: after which, it then decreases until it becomes invisible. It appears every year in its greatest lustre, thirty-two or thirty-three days earlier than in the foregoing year; so that its revolution is completed in about three hundred and thirty-three days.

In the years 1612, and 1613, there appeared a cloudy star in the girdle of Andromeda; which disappeared until the year 1664, and then appeared again.

There is another star, between Eridanus and the Hare, which also shows itself, and then withdraws, like the former.

There is one star of the fourth magnitude, with two of the fifth, in Cassiopeia, which in all probability are new ones.

Mr. Cassini has observed four towards the Artick pole, which are probably new ones too.

Some stars formerly appearing, do now disappear. One such there was in Ursa Minor. Another or two in Andromeda. One which Tycho Brahe inserts in his catalogue, for the twentieth of Pisces. For time out of mind, there were seven stars observed in the pleiades. The writer of Astronomy's advancement inquires, whether the seven stars in the first of the Revelation have no allusion to them. However, at present there are but six *to be seen, probably* one of them is retired,

Mr. Derham thinks these new stars may be planets belonging to some of the systems of the fixed stars, and those planets become visible, when they are in that part of their orbits which is nearest the earth, and again gradually disappear, as they move in their orbits farther from us.

It is a surprising observation of Dr. Cheyne: "Supposing that every fixed star is a sun, and governs in a mundine space, equal to our system, then there must be only as many fixed stars of the first magnitude, as there are systems that can stand round ours. But there are but about twelve or thirteen spheres that can stand round a middle one, equal to them: and so many are the stars of the first magnitude. Again, if we examine how many spheres can stand round this first range of spheres, we shall find their number between forty eight and fifty two. And so we find the number of the stars of the second magnitude. As for the several other magnitudes, it is not altogether possible to determine their number, because they are not so distinguishable from those of the other magnitudes, as the first and second are." He adds most reasonably and religiously: "It is impossible for any body seriously to consider in his mind, what is certain about these heavenly bodies, and to hinder himself from being ravished with the power and wisdom of the great God of heaven and earth!"

Mr. Derham supposes the particular star Syrius to be above two millions of millions of miles distant from us.

Dr. Grew, from a very probable computation, makes the distance of the Pole Star from the earth to be four hundred and seventy millions, and eight hundred and forty thousand miles.

Considering the mean and vile fables of the pagan poetry, yea, and the scandalous actions of some greater devils among the pagans, which are commemorated and celebrated in the names which our globes give to the constellations, I cannot but move you, O Christian astronomers, to attempt a reformation of so shameful an abuse. For shame, let those glorious bodies no longer suffer the affronts of our base denominations. To put Christian names on the constellations, and allowing the present figures upon our globes to remain still as they are, nevertheless to transfer them into scriptural stories, was a thing endeavoured by Schillerus, and by Novidius.

The caution used in the ancient Hebraic and Arabic astronomy, about the names of the constellations, is well known to all who are versed in antiquities. Dismissing that reflection, what remains is this: a learned Frenchman pretends to tell us, That the stars in the heavens do stand in the form of Hebrew letters, and that it is possible to read there, whatever is to happen of importance throughout the universe. Amazing! that so much learning should be consistent with, and much more, that it should be subservient to such futilities! The true reading of the stars is to look up, and spell out, the glorious perfections of that God, who is the Father of those lights, and who made and moves them all.

"I would by no means look up to the stars, with the foolish astrology of the star gazers, who try to read, what the great God that made them has not written there. But there is very plainly to be read there, the power and the grandeur of

the glorious God. This I will observe, prostrate in the dust before Him. The heavens declare the glory of God; and shall not I observe it? When I consider thy heavens, O Lord, and the stars which thou hast ordained, I cannot but cry out, What is man, that thou art mindful of him, and the son of man, that thou visitest him!

"Unto the father of the faithful, my God said, Look now toward heaven, and tell the stars, if thou be able to number them; so shall thy offspring be. Glorious Lord, make me one of them. A worm of the dust, filled with the love of God and of his neighbour, becomes a star in the eye of the glorious God: and if he be one of much grace, and one of much use, he is then a star of the greater magnitude.

"God, my maker and theirs, gives me that song for the night, wherein I view them; he tells the number of the stars; he calls them all by their names. It is true of the just, who are to shine as the stars for ever and ever. May I be known by the Lord as one of that number, and have a name in his book of life!

"Are the very stars themselves liable to vicissitudes? And shall not I look for them in this our miserable world?

"How little can I comprehend the condition and intention of the stars? O incomprehensible God, I will not cavil, but adore, when I find mysteries in thy providence, altogether beyond my penetration!"

ESSAY IV. *Of the* SUN.

A most glorious and most useful creature! But still a creature! By old astronomers called

the heart of the planets. There will be no Athenians now to arraign me if I call him the carbuncle of the heavens. Kircher supposes the Sun to be a body of fire, unequal in surface, composed of parts which are of a different nature, some fluid, some solid. The disk of it, a sea of fire, wherein waves of astonishing flame have a perpetual agitation.

Sir Isaac Newton, as well as Dr. Hook, takes the Sun to be a solid and opaque body. Dr. Hook thinks this body to be encompassed with a vast atmosphere, the shell whereof is all that shines. The light of the Sun he takes to be from the burning of the more superficial parts, which are set on fire, which may be without hazard of being burnt out in a vast number of ages. And Sir Isaac Newton thinks the Sun to be a sort of a mighty earth, most vehemently hot; the heat whereof is preserved by the astonishing magnitude of the body, and the mutual action and reaction between that, and the light emitted from it. Its parts are kept from fuming away, not only by its fixity, but also by the density and vast weight of the atmosphere incumbent on it. The light seems to be emitted much after the manner as iron, when heated to such a degree, as to be just going into fusion, by the vibrating motion of its parts, emits with violence plentiful streams of liquid fire. So great a body will continue its heat a great while, perhaps in proportion to its diameter.

Upon the convexity of the body of the Sun, there are observed black spots, which are moveable, and changable. These move regularly towards the west, and finish their revolution in about

five and twenty days; and so testify to us, that the Sun turns upon its own centre: the axis of the motion inclining to the ecliptic.

These solar spots are probably evaporations, which arise from the body of the Sun, somewhat as vapours do from the earth; and they form themselves into clouds. That which adds to this probability, is, that the spots are always changable in their bulk, form, and configuration. Sometimes their number is greater, and sometimes less, and sometimes there are none at all. Some of them shine, and others that shone, become dark. Diligent astronomers, who have waited on them for nine or ten years together, have never found them in all this time to return to the same configuration. In Charlemaign's time, every one saw a spot in this great luminary. And there have been divers days together, (as in the year 1547,) wherein the Sun has appeared little brighter than the Moon in her total eclipse, and the stars have been visible at noon day. Virgil and Ovid intimate such a darkness upon the Sun once for a whole year together, that the fruits of the earth could not be ripened.

The apparent diameter of the Sun being sensibly greater in December than in June, it is plain, and observation confirms it, that the Sun is proportionably nearer to the earth in winter than in summer. It is also confirmed, by the earth's moving swifter in December than in June; which it does about five fifteenths. And for this reason there are about eight days more from the Sun's vernal equinox to the autumnal, than from the autumnal to the vernal.

Mr. Tompion's observations, from the equa-

tion of natural days, render it evident, that the motion of the Sun (if we may speak in those terms) must be swifter at some times, than at others. Great God, the motion is always under thy glorious guidance!

According to Cassini, the Sun's mean distance from the earth is 22,000 semidiameters of the earth. And the Sun's diameter is equal to 100 diameters of the earth: And therefore the body of the Sun must be 1,000,000 times greater than the earth.

Cassini more directly expresses himself; that the Sun's distance from the earth is 172,800,000 English miles.

Take Mr. Derham's computation; Saturn is computed at 93,451 miles in diameter, and consequently 427,318,300,000,000 miles in bulk: Jupiter at 120,653 miles in diameter, and by consequence 920,011,200,000,000 miles in bulk. But yet as amazing masses as these all are, they are all far outdone by that globe of fire, the Sun: which, as it is the fountain of light and heat unto all the planets about it, by its kind influences affording them the great comforts of life; so does it in bulk surpass them all. Its diameter is computed at 822,148 miles; and so there must be 290,971,000,000,000,000 miles in the solid content of it.

Dr. Grew is of opinion, that for ought we know, the Sun may afford us his light, without such an intense heat, as has been imagined. The beams of the Sun, he thinks, may first conceive their heat, when they come to be mixed with our atmosphere. There are things intensely hot, which give no light at all; but rotten wood, or

fish, and the glow worm, and some other bodies, give a brisk light, without any heat. Light and heat, he thinks, have no necessary conjunction, at least not in any sensible proportion. It is known also, how necessary the air is to produce fire, and even light itself, in some of those bodies that shine in the dark. If the Sun were a burning body, and the heat of it so much greater than that we feel of it, as to be in proportion to its distance; how comes the substance of it so little to be altered by so intense a heat, and to hold this heat with so great an equality for near six thousand years? One way or the other; either so luminous a body without fire, or so burning a body, not consumed or altered; it is wonderful!

But Sir Isaac Newton supposes, that a very large dense, and fixed body, when heated beyond such a degree, may emit light so copiously, that by such emission, and by the re-action of its light, and by the reflection and refraction of the rays within its hidden meatus, it may come to grow still hotter and hotter, as deriving more degrees of heat by those ways, than it can of cold by any other. Thus he supposes the Sun a vast globe that is vehemently heated, and the heat thereof preserved by its great magnitude, and the mutual action and re-action which there is between it, and the light emitted by it. And its parts are preserved from evaporating in flame and fume, not only by the great fixity of its nature, but also by the mighty weight and thickness of the atmosphere, which environs it, and condenses its vapours, whenever they are emitted.

However, behold the Sun seated by the glorious God, like a powerful monarch, on his throne, (as

Dr. Cheyne expresses it) from thence distributing light, and life, and warmth, in a plentiful effusion, to all the attendants that surround him; and that so equally, that the nearest have not too much, nor the farthest too little: his bulk and situation so contrived, in respect of the planets, as to have quantity of matter just enough to draw round him these massy bodies, and their satellites, who are so various in their quantities, and their distances, and that in regular and uniform orbits. The doctor says well, these are things that clearly speak the omnipotence and omniscience of their Author.

What a fancy is that of Dr. Wittie, that the Sun is probably the seat of the blessed! the Sun which is the centre of the heavens, and the seat of inherent light. It is true, of the blessed we read, they shall shine as the Sun; and their blessedness is called, the inheritance of the saints in light. But this is very short of demonstration, that the saints must be lodged there. Though the church militant were once represented as clothed with the Sun, it follows not, that the church triumphant dwell in the Sun.

And Mr. Arndt propounds a thought, which cannot be too much dwelt upon: as the Sun is the ornament of the heavens, so is Christ the ornament of his church.

Dr. Cheyne with good reason apprehends, that the quantity of light and heat in the Sun is daily decreasing. It is perpetually emitting millions of rays, which do not return into it. Bodies attract them, and suffocate them, and imprison them; and they go no more back into their fountain.

Mr. Bernoulli, from the flashes of the light, in

the vacuity of a tube accommodated with mercury, whereby a dark room is enlightened, renders it likely that our atmosphere, and all the bodies on our globe, are saturated at all times with rays of light, which never do return to their fountain.

It is true, this decrease of the Sun is very inconsiderable. It shews that the particles of light are extremely small, since the Sun for so many ages has been constantly emitting oceans of rays, without any very sensible diminution. However it is from hence evident, that the Sun had a beginning; it could not have been from eternity; eternity must have wasted it: it had long ere now been reduced unto less than the light of a candle.

Glorious God, thou art the father of lights, the maker of the Sun!

In a late act of the faith, as they call their inhuman butcheries, performed by that execrable hell upon earth, the inquisition in Portugal; a confessor being brought forth to die a grievous death, as soon as he came to the light of the Sun, which he had not seen for some years before, he broke forth into this expression, Who that has reason in him, could worship any but the Maker of that glorious creature! they gagged him immediately!

My pen shall not be served so. Enjoying the benefits of the Sun, I will glorify him that made it: thou alone art for ever to be adored, O thou Maker of that glorious creature!

An eminent writer of natural theology has this remark, that the Sun is the image of those, who exercise authority over others. And that all superiors in every station, looking towards the Sun, should have shot to their minds the rays of such

thoughts as these; what good influences ought I to dispense to those that have dependence on me!

The apocryphal Book of Wisdom does wisely, to call the light of the Sun, an image of the divine goodness.

The diameter of the earth is near eight thousand miles; and the diameter of the great orbit ten thousand diameters of the earth. This great orbit or the orbit of the earth, in its annual revolution about the Sun, Dr. Gregory makes the semidiameter of it 94,696,969 English miles: which is the distance of the earth from the Sun. But the semi-diameter of Saturn's orbit is no less than ten times as great. All astronomers before Kepler, supposed this orbit a perfect circle; but he has proved it an ellipsis. If our solar system have such large dimensions, and if every fixed star be a Sun, that has a system, of the like dimensions perhaps, belonging to it: great is our God, and greatly to be praised: his greatness is unsearchable! How is it possible to consider the grandeur of our God, without annihilating ourselves before Him, or without horror at the view of the matchless evil, in sinning against so glorious a majesty!

It is a passage in a little treatise, entitled, the Book of Nature; not unworthy to be transcribed here: "If thou never observe the sky with thine eyes, but to guess at rain and fair weather; or if thy looking up to heaven be bounded with the starry firmament; and if thou removest from thee the love and honour of God, and the contemplation of Him who dwelleth in the heavens, thou hast no cause to raise thyself above the brutes, thy fellow inhabitants of this lower world."

How glorious will the righteous be in that world, *when they shall* shine as the Sun?

ESSAY V. *Of* SATURN.

ALL the primary planets move about the Sun, as their common centre. They move with different velocities: but there is this common law observed in all of them; that the squares of the times of their revolutions, are proportional to the cubes of their distances. And the secondary planets observe the same law in their motions about their primary planets. And another common law with them, is, that lines drawn from the foci of the curves they move in, to their bodies, will sweep over equal areas in equal times on the planes of other orbits. Who but the great God could make and fix these laws? Lord, they continue this day according to thine ordinances, for all are thy servants.

It is now found, that Saturn, besides his round body, has also a luminous ring, which encompasses him, as the horizons of our artificial globes do usually encompass them; and is flat upon the verge, as they use to be. The ring shews itself in an oval, and at certain times it wholly disappears. It appears not, however, that Saturn revolves upon his own centre.

When this planet appears at 20 deg. 30 min. of Pisces and of Libra, then it is that he appears round; or without his ansæ, as they are called, which is once in fifteen years; or half his course, which every one knows to be completed in thirty years, or 10,950 days.

The ring seems to be opaque and solid, encompassing the planet, but no where touching it. The diameter of it is two and a quarter of Saturn's diameters; and the distance of the ring from the planet is about the breadth of the ring itself. Mr.

Hugens takes the breadth of the ring to be about six hundred German miles.

The proportion of the body of Saturn to the Earth, is that of 30 to 1. The distance of Saturn from the Sun is about ten times as great as the distance of our Earth from him; and by consequence, that planet will not have above an hundredth part of that influence from the Sun, which this Earth enjoys.

The ring of Saturn, being distant from him no more than $2\frac{1}{4}$ of his semidiameters, it cannot be seen at the distance of 64 degrees from Saturn's equator, in whose plane the ring is placed. So that there is a zone of almost 53 degrees broad, towards either pole, to which this famous ring does never appear. Saturn is attended with five satellites. The first satellite makes a revolution about Saturn in 1 day, 21 hours, and 19 minutes; and makes two conjunctions with Saturn in less than two days. It is distant from the centre of Saturn $4\frac{3}{8}$ of his semidiameters. The second makes his revolution in 2 days, 17 hours, and 43 minutes. It is distant from Saturn $5\frac{3}{7}$ semidiameters of the planet. The third is distant from Saturn 8 of his semidiameters, and makes his revolution in almost $4\frac{3}{7}$ days. The fourth revolves in 15 days, 22 hours, 41 minutes. It is distant from the centre of Saturn about 18 of his semidiameters. The fifth is distant from the centre of Saturn 54 of his semidiameters, and revolves about him in $79\frac{1}{3}$ days.

Mr. Huygens, who first of all discovered the fourth, (for which cause it is called the Huygenian satellite, though Dr. Halley afterwards corrected the theory of its motion) thinks, the mighty dis-

tance between the fourth and fifth satellites to be a ground for suspicion, that there may be a sixth between them, or that the fifth may be attended with some of his own. On the revolutions of the planets, the incomparable sir Richard Blackmore, in his noble poem of Creation, thus moves us to consider the first cause of all:

> Saturn in thirty years his ring completes,
> Which swifter Jupiter in twelve repeats.
> Mars three and twenty months revolving spends,
> The Earth in twelve her annual journey ends.
> Venus, thy race in twice four months is run:
> For his Mercurius three demands; the Moon
> Her revolution finishes in one.
> If all at once are mov'd, and by one spring,
> Why so unequal is their annual ring?

The motions of the heavenly bodies can be produced and governed by none but an infinite God. It is well argued by Lactantius: "There is indeed a power in the stars, of performing their motions; but that is the power of God who made and governs all things, not of the stars themselves that are moved." And by Plato before him; "Let us think, how it is possible for so prodigious a mass to be carried round for so long a time by any natural cause? For which reason I assert God to be the cause, and that it is impossible it should be otherwise.

ESSAY VI. *Of* JUPITER.

JUPITER, according to Cassini's measures, must be greater than that of the Earth, by 2460 times. The periodical time of his revolution about the Sun, is 12 years, or 4380 days.

In the body of Jupiter, and over his luminous part, there are observed three darkish belts, like

the spots which appear in the Moon. These belts or girdles are near straight and parallel, and extending from east to west, after the manner of the ecliptic. They make a kind of equinoctial with tropics. The southern is larger a little than the northern, and a little nearer to the south than the other is to the north.

Dr. Hook has observed also a small and a dark filament, and the zones growing a little darker, as they draw nearer to the poles. And some have observed in them something of curvity, though their borders are perfectly round.

Jupiter has four satellites, or little moons, waiting on him. The nearest is distant from him, according to Mr. Flamstead's most accurate observations, a little more than five of his semidiameters; and finishes his course in 1 day, 18 hours, 28 minutes, and a few seconds. The second is distant from him about 8 of his semidiameters, and finishes his course in 3 days, 13 hours, 17 minutes, and a few seconds. The third is distant from him about 14 of his semidiameters, and finishes his course in 7 days, 3 hours, 59 minutes, and some seconds. The fourth is distant from him about 24 of his semidiameters, and finishes his course in 16 days, 18 hours, 5 minutes and some seconds. These guards of Jupiter cast a shadow upon him, when they are found interposed between the sun and him.

The fourth would appear to an eye in Jupiter, as big as the moon does to us. A spectator there would have also four kinds of months. In one of Jupiter's years, which is twelve of ours, there would be 2407 of the least months; half that number for the next satellite: the months of the third

would be near subduple of the second, or subquaduple of the first: the months of the greatest would be about 254. A year of Jupiter has a great number of days; but of the four sorts of months, the least contains only four days and a quarter; the greatest something more than forty.

Mr. Cassini has observed a couple of spots in the body of Jupiter, which make a revolution on the centre of this planet, from east to west, in about 9 hours and 56 minutes. Others have lately confirmed it by better observations. This proves, that the planet moves about upon its own centre. Behold the *shortest period* that is made in the firmament! the days and the nights, each of them *five hours* apiece.

Campani observed, with a more than ordinary telescope, certain protuberances and inequalities in the surface of this planet.

We may here insert a remark upon the periodical motions of the planets; both the primary and their secondaries. One thing very considerable in the periodical motion of the secondary planets, is, that it is mixed with a kind of cochleous direction towards one or other pole of its primary planet; by which means every satellite, by gentle degrees, changes its latitude, and makes its visits towards each pole of its primary.

We will here break off with the words of Mr. Molynex. "From hence may we justly fall into the deepest admiration, that one and the same law of motion should be observed in bodies so vastly distant from each other, and which seem to have no dependence or correspondence with each other. This doth most evidently demonstrate, that they were all at first put into motion by one and the

same unerring hand, even the infinite power and wisdom of God, who hath fixed this order among them all, and hath established a law which they cannot transgress.

Chance, or dull matter, could never produce such harmonious regularity in the motion of bodies so vastly distant: this shews a design and intention in the first Mover.

ESSAY VII. *Of* MARS.

MARS borrows his light from the Sun, as well as the rest of his planetary brethren. He has his increase and his decrease of light, like the Moon; may be seen almost bisected, when in his quadrature with the Sun, or in his perigæon; though never corniculated or forked, like his inferiors.

Dr. Hook discovered several spots in Mars, and particularly a triangular one, which has a motion. Mr. Cassini afterwards discovered four spots, the two first on one face of Mars, afterwards two more that were larger, on the other face. Upon further observation it was found, that the spots of these two faces turned by little and little from east to west, and returned at the space of twenty four hours and forty minutes. In such a term therefore, there is a revolution of Mars upon his own axis.

The year of Mars is near twice as long as ours; his natural day a little greater than ours: his artificial day is almost every where equal to his night, besides what belongs to twilight. Mars as well as Jupiter has a perpetual equinox. Hence there can be but little variety of seasons in any one particular place of these planets.

Whence the fasciæ, or fillets observed in Mars?

There appear certain swathes, as we may call them, which are placed parallel to his equator. Are they owing to the heat and cold there, like our clouds and snows?

It is thought that Mars has an atmosphere, because fixed stars are obscured, and as it were extinct, when they are seen just by his body.

ESSAY VIII. *Of* VENUS.

VENUS has various appearances; round sometimes; anon half round; by and by like a crescent.

Mr. Cassini discovered certain spots on this planet, by the motion whereof it appeared that it moved upon its own centre, and upon an axis, which carries it from north to south; a motion wholly unknown any where else in the heavens. Two spots it has, which are very thin, long, uncertainly terminated; and a shining part belongs to one of them.

He discovered also, as he judges, a satellite attending this planet; which Dr. Gregory assents to, as more than probable. This is not usually seen, perhaps because it may not have a fit surface to reflect the light of the Sun; which is the case of the spots in the Moon.

Herigone, and Keplerus, and Rhætensis, conclude, that Venus moves about its axis in fourteen hours. Dr. Cheyne says in twenty three.

ESSAY IX. *Of* MERCURY.

THE great Hevelius hath observed, that Mercury changes his face, like Venus, and like our moon; appearing sometimes round, sometimes *half round*, sometimes like a crescent.

This planet has his abode so near the Sun, that as yet there has been little discovered of him.

It appears not yet, whether he revolves upon his own axis, and so what may be the length of his days. But it is probable he may have such a motion, as well as the other planets. However, his year is hardly equal to a quarter of ours.

Sir Isaac Newton has terrible apprehensions of the heat in this planet, as being seven times as much as the heat of the summer sun in England; which according to his experiments made by the thermoscope, would be enough to make water boil. If the bodies in this planet be not enkindled by this heat, they must be of a peculiar density. But Mr. Azout pretends to prove, that though this planet be so near the Sun, yet the light there is not capable of burning any objects.

ASTRONOMICAL SYNOPSIS.

Adapted to modern improvements in this science.

Names.	Diameter.	Mean distances from the Sun.	Periodical Revolution. Y.	D.	H.	M.	S.
Sun	883,246						
Mercury	3,224	36,583,825	0	87	23	14	33
Venus	7,687	68,360,058	0	124	16	41	37
Earth	7,928	94,507,428	1	0	5	48	48
Moon	2,180	94,507,428	0	27	7	43	5
Mars	4,189	144,000 023	1	321	22	18	27
Jupiter	89,170	491,702,304	11	315	14	39	2
Saturn	79,042	901,668,908	29	164	7	21	50
Herschel	35,112	1,803,534,392	83	294	8	39	0

"Great God, thou hast lifted me up to heaven; Oh! let me not after all be cast down to hell. The philosopher, who gazing on the stars with his attentive observation, tumbled into a pit that he observed not, was not so unhappy as he that has visited heaven on the noble intentions of astronomy, but by an ungodly life, procures to him-

self a condemnation to that hell, which is a state and place of utter darkness. Wretched astronomers! who are among the wandering stars, to whom is reserved the blackness of darkness for ever."

We will conclude what we collect about the stars, with transcribing a passage out of the Miscellanea Curiosa. "The honourable Mr. Roberts computes the distances of the fixed stars; which he supposes to be so many suns of a different magnitude. He thinks, that it seems hardly within the reach of any of our methods to determine it. The diameter of the earth's orb, which is at least one hundred and sixty millions of miles, is but a point in comparison of it. At least nine parts in ten, of the space between us and the fixed stars, can receive no greater light from the Sun, or any of the stars, than what we have from the Sun in a clear night. Light takes up more time in travelling from the stars to us, than we in making a West India voyage, which is ordinarily performed in six weeks. A sound would not arrive to us from thence in fifty thousand years, nor a cannon bullet in a much longer time. This is easily computed, by allowing ten minutes for the journey of light from the Sun hither; and that sound moves about thirteen hundred feet in a second."

ESSAY X. *Of* Comets.

It is an admirable work of our God, that the many globes in the universe are placed at such distances, as to avoid all violent shocks upon one another. Even comets too, move so as to serve the holy ends of their Creator! Comets, which

are commonly called blazing stars, appear by later observations to be a sort of excentrical planets, that move periodically about the Sun.

Sir Isaac Newton, from whom it is a difficult thing to dissent in any thing that belongs to philosophy, concludes, that the bodies of comets are solid, compact, fixed, and durable, even like those of the other planets.

He has a very critical thought upon the heat, which these bodies may suffer in their transits near the Sun. A famous one, in the year 1680, passed so near the Sun, that the heat of the Sun in it must have been 28,000 times as intense as it is in England at midsummer; whereas the heat of boiling water, as he tried, is but little more than the dry earth of that island, exposed to the midsummer sun: and the heat of red hot iron he takes to be three or four times as great as that of boiling water. Wherefore the heat of that comet in its perihelion was near two thousand times as great as that of red hot iron. If it had been an aggregate of nothing but exhalations, the Sun would have rendered it invisible. A globe of red hot iron, of the dimensions of our earth, would scarce be cool, by his computation, in 50,000 years. If then this comet cooled an hundred times as fast as red hot iron, yet, since his heat was 2000 times greater than that of red hot iron, if you suppose his body no greater than that of this earth, he will not be cool in a million of years.

The tails of comets, which are longest and largest just after their perihelions, he takes to be a long and very thin smoke, or a mighty train of vapours, which the ignited nucleus or the head of

the comet, emits from it. And he easily and thoroughly confounds the silly notion of their being only the beams of the Sun, shining through the head of the star.

The phenomena of the tails of comets depend upon the motion of their heads, and have their matter supplied from thence.

There may arise from the atmosphere of comets, vapours enough to take up such immense spaces, as we see they do. Computations made of and from the rarity of our air, which by and by issue in astonishment, will render this matter evident.

That the tails of comets are extremely rare, is apparent from this; the fixed stars appearing so plainly through them.

The atmosphere of comets, as they descend towards the Sun, is very sensibly diminished by their vast running out, that they may afford matter to produce the blaze. Hevelius has observed, that their atmosphere is enlarged, when they do not so much run out into tail. This lucid train sometimes, as Dr. Cheyne observes, extends to four hundred thousand miles above the body of the star.

Sir Isaac Newton has an apprehension, which is a little surprising, that those vapours which are dilated, and go off in the blazes of comets, and are diffused through all the celestial regions, may by little and little, by their own proper gravity, be attracted into the planets, and become intermingled with their atmospheres. As to the constitution of such an earth as ours, it is necessary there should be seas; thus, for the conservation of the seas, and the moisture of the planets, there may

be a necessity of comets, from whose condensed vapours, all that moisture, which is consumed in vegetations and putrefactions, and so turned into dry earth, may by degrees be continually supplied, repaired, and recruited. Yea, he has a suspicion, that the spirit which is the finest, the most subtile, and the very best part of our air, and which is necessarily requisite to the life and being of all things, comes chiefly from comets, If this be so, the appearance of comets is not so dreadful a thing, as has been represented.

Mr. Cassini will thus far allow bad presages to comets, that if the tail of a comet should be too much intermingled with our atmosphere, or if the matter of it should, by its gravity, fall down upon our earth; it may induce those changes in our air, whereof we should be very sensible.

Bernoulli, in his system of comets, supposes, that there is a primary planet, revolving round the Sun in the space of four years and 157 days; and at the distance of 2,583 semidiameters of the great orbit. This primary planet, he supposes, either from his mighty distance, or his minute size, to be not visible to us; but however, to have several satellites moving round him, though none descending so low as the orbit of Saturn; and that these becoming visible when in their perigæon, are what we call comets.

Seneca's prediction, that a time should come, when our mysteries of comets should be unfolded, seems almost accomplished. However Seneca has not obliged us with the phenomena observed by him, which encouraged this prediction.

No histories of comets were of service to the theory of them, till Nicephorus Gregoras, an

astronomer of Constantinople, described the path of a corner in 1337. All that considered comets until Tycho Brahe, considered them as no other than vapours below the Moon.

Anon, the sagacious Kepler improving on Tycho's discoveries, came at a true system of comets, and found, that they moved freely through the planetary orbs, with a motion that is not much different from a rectilinear one.

The incomparable Hevelius went on, and though he embraced the Keplerian hypothesis, of the rectilinear motion of comets, yet he was aware, that the path of a comet was bent into a curve line towards the Sun.

At last the illustrious Sir Isaac Newton, arrives with demonstrations, that all the phenomena of comets would naturally follow from the Keplerian principles. He shewed a method of delineating the orbits of comets geometrically; which caused admiration in all that considered and comprehended it.

The most ingenious Dr. Halley has made calculations, upon which he ventures to foretell the return of comets; but he observes, that some of them have their nodes pretty near the annual orb of the earth. I will transcribe the words he concludes with: "What may be the consequences of so near an appulse, or of a contact, or lastly, of a shock of the celestial bodies, (which is by no means impossible to come to pass) I leave to be discussed by the studious of physical matters."

The sentiments of so acute a philosopher as Dr. Cheyne upon comets, deserve to be transcribed.

"I think it most probable, that these frightful bodies are the ministers of divine justice, and in

their visits lend us benign or noxious vapours, according to the designs of Providence; that they may have brought, and may still bring about the great catastrophe of our system; and, that they may be the habitation of animals in a state of punishment, which if it did not look too notional, there are many arguments to render not improbable. And elsewhere: it is most likely, they are the ministers of divine justice, sending baneful steams, from their long trains, upon the planets they come nigh. However, from them we may learn, that the divine vengeance may find a seat for the punishment of his disobedient creatures, without being put to the expense of a new creation."

When I see a vast comet, blazing and rolling about the unmeasurable ether, I will think; "who can tell, but I now see a wicked world made a fiery oven in the time of the anger of God! the Lord swallowing them up in his wrath, and the fire devouring them! What prodigious mischief and ruin might such a ball of confusion bring upon our sinful globe, if the great God order its approach to us!

"How happy they, that are in the favour and friendship of that glorious Lord, who knows how to deliver the pious out of distresses, and reserve the unjust for a punishment of a day of judgment!

APPENDIX. *Of* HEAT.

WE should be forgetful, if we take our leave of the heavenly bodies, and say nothing of heat, whereof they have so much among them.

To the heat of bodies it is requisite, that the small parts of it be agitated with much vehe-

mence and rapidity; and that the determinations of the insensible corpuscles thus agitated be also very various; and that likewise the variously agitated particles be so small, as generally speaking to be singly insensible: for unless they be exceeding fine, they cannot penetrate readily into the pores of contiguous bodies, and so warm or burn them.

The operation of heat upon our senses, the result of which we commonly call heat, is usually estimated by its relation to the organs of our feeling. If the motion of the small parts be more languid in the object, than it is in the sentient, we pronounce the body to be cold; but if it be more violent in the object than in the sentient, we say the body is hot.

The intenseness of heat, as of light, always is as the density of the rays, or particles of fire, that occasion it; and this density is as the distance from the radiating point reciprocally.

Dr. Slare has published surprising experiments of producing fire and flame from the bare mixture of two liquors actually cold; a vegetable oil, and a compound spirit of nitre.

The incredible force of burning glasses. A burning concave, made at Lusace in Germany, near three Leipsic ells in diameter, and of a copperplate, scarce twice as thick as the back of a common knife, makes wood in the focus (which is two ells off) to flame in a moment; and water in an earthen pot boil immediately: tin three inches thick, to be melted quite through in three minutes; a plate of iron to be presently hot, and very quickly perforated: it will run in five or six minutes; tiles, slates, and earthern pots, melt in a little time,

and run into glass; a clod of earth turns into a greenish glass.

Mr. Tschirnhaus makes convex burning glasses of three or four feet diameter, the focus at the distance of twelve feet diameter; which in a moment vitrify tiles, slates, pumice stones and earthen vessels; melt all resinous things under water; melt all metals in a moment, and gold itself is turned into glass of a purple colour: of such efficacy are the rays, when stripped of an unctious matter, with which we may suppose them generally clothed.

"The ancient Persians were the worshippers of fire: but I abhor their fire places. The Indians of my country, while unchristianized, concluded from the strange effects of fire, it must be a god. I will adore the glorious God who made the fire. Great God, I bless thee for the benefits, which thy creatures, and I among them, receive by the fire, which is brought from heaven to us. May my zeal for thy service be always kept boiling in the heat proper for it.

"Since fire is thus irresistible, and heat so insupportable, surely I should beware of that impiety, which will expose me to the vengeance of God. Who can dwell with such a devouring fire, such everlasting burnings? My God, be not thou unto me a consuming fire. My God, who can abide the heat of thine anger!" I have seen a book of devotion, entitled, a Disciple warming himself, and owning his Lord. It is there actually evident, and performed, that this one object, the fire on the hearth, will afford volumes of profitable contemplations.

ESSAY XI. *Of the* MOON.

WE are now coming down to our terraqueous globe. The Moon, a sort of satellite to this globe, salutes us in our way. Paying a homage to none but her glorious Maker, we will now behold her walking in her brightness.

What shall we think of the protuberant parts observed on that celestial body? What of the round hollows, like pits or wells of several magnitudes, which have been formerly mistaken for mountains? The periodical revolution of the Moon, in reference to the fixed stars, according to Mr. Flamstead, is 27 days, 7 hours, 43 minutes, 7 seconds.

In the same space, with a strange correspondence of the two motions, it revolves the same way about its own axis; by which the same side is always exposed to our sight. But because in the space of a periodical month, the Earth is also with this her satellite, moved on almost an entire sign, the Moon cannot come to a new conjunction with the Sun, but wants 2 days and 5 hours of it; which must be passed before the entire lunation will be over, and before the Moon has exhibited all her phases. These 2 days and 5 hours, added to the periodical month, make the synodical one; which is 29 days, 12 hours and 45 minutes.

Those librations of the Moon's body, which occasion that the hemisphere exposed to our sight is not always exactly and precisely the same, arise from the eccentricity of the Moon's orbit, and from the perturbations it suffers by the Sun's attraction, and from the obliquity of the axis of the diurnal rotation of the Moon's own orbit. Without the knowledge of these things, the phenomena of the

Moon would be inexplicable: but upon the consideration of these, they are very demonstrable.

It is very sure, that although it be almost the same face which the Moon turns to the Earth, yet it is not entirely so. There is a libratory motion, whence it comes to pass, that sometimes the more eastern and western parts of it, sometimes the more northern and southern appear alternately.

According to Sir Isaac Newton, the mean distance of the Moon from the Earth, is about 60 semidiameters of the Earth; or about 24,000 English miles. The mean diameter of the Moon is 32 minutes, 12 seconds; as the Sun's is 31 minutes, 27 seconds. The density of the Moon, to that of the Earth, he concludes to be nearly as 9 to 5. And the mass of matter in the Moon, to that of the Earth, to be nearly as 1 to 26.

The Moon hath properly no atmosphere, such as belongs to our earth, of clouds, winds, thunders; her face is always clear, and by our telescopes we can see the Sun's light pass regularly and uniformly, from one mountainous place to another.

The light of the Moon reflected on us, is of such a weakness, that even in the full moon, it can be brought by no burning glass to afford the least degree of heat. The rays have their force decreased, at least as the square of their distance. The force of the sun's rays reflected to us from the Moon, to those that come to us directly, is decreased, at least in proportion of the square of the Moon's distance from the earth, to the square of the Moon's semidiameter. And by calculation it will be found, that the light of the Moon brought hither, will be in force but the fifty thousandth

part of what comes hither directly from the sun.

Dr. Hook finds, that the quantity of light which falls upon the hemisphere of the full Moon is rarefied into a sphere about 288 greater in diameter than the Moon, before it arrive to us. Consequently, the moon's light is 104,368 times weaker than the sun's; and it would require 104,368 full moons to give a light equal to that of the sun at noon.

There is a secondary light of the Moon; that is to say, the obscure part of the Moon appears like to kindled ashes, just before and after the change. This is the sun's rays reflected from the bright hemisphere of the earth, to the dark parts of the Moon; and thence again reflected to the earth, destitute of the light of the sun. This is by Tacquet and Zucchius more largely discoursed on. When the Moon is at change to us, the earth is at full to the moon; and the light of the earth is about fifteen times greater than that of the Moon. The Moon also being so little, as not to obscure above a twentieth part of the earth, it may be supposed that the light from the earth may render her a little visible to us even in solar eclipses.

The Moon is almost one semidiameter of the earth nearer to us, when she is in the meridian, than when she is nigh the horizon. But why doth she then appear bigger to our sight when she is nigh the horizon, than when she is in the meridian? Dr. Wallis agrees with Des Cartes in the solution: the horizontal Moon is capable of being compared with many intervening objects, hills, trees, and the like; but the meridian Moon hath nothing to be compared with.

Though the Moon, as well as the earth, and

probably all the planets be of a figure oblately spheriodical, that is to say, having its diameter at the equator, longer than its axis; yet the excess of the equatorial diameter in her is so inconsiderable, that she may well enough pass for a globe. And perhaps this almost spherical figure of the Moon may be the result of her slow motion round her axis; for Jupiter, which moves the swiftest of any round its axis, is of a figure more oblate than any other planet.

Dr. Cheyne observes, if our Moon were bigger, or nearer the earth, or if we had more than one, we should be every now and then in hazard of being drowned. And if our present Moon were less, or at a greater distance, or if there were none at all, we should be in hazard of being stifled with the baneful steams of a stagnated ocean. It is evident our satellite is most wisely contrived for our purposes, by thee, O our gracious God.

The incomparable Sir Isaac Newton has at length obliged the world with a Theory of the Moon, which has performed that which former astronomers thought almost impossible.

Hugenius had glasses in perfection, and wrote since the accurate maps of the Moon, taken by Hevelius and Ricciolus; but he could observe no seas and rivers there. It is also argued, that if any such were there, they could not but raise a mighty atmosphere, and such clouds as must needs darken the body of the Moon, sometimes in one part, sometimes in another. They carry on their inferences; if no waters in the Moon, then there are no plants, animals, nor men. About the constitution of this queen of the night, there seems a necessity for us to remain in the dark; for

Mr. Derham has confuted Hugenius with his own glasses, and has demonstrated, that there are great collections of waters in the Moon, and by consequence, rivers, vapours, and air; and in a word, a considerable apparatus for habitation. But by what creatures inhabited? A difficulty this, that cannot be solved without revelation.

"My God, I bless thee for that luminary, by which we have the uncomfortable darkness of our night so much abated. That luminary, the influences whereof have such a part in the flux and reflux of our seas; without which we should be very miserable. That luminary, whose influences are so sensibly felt in the growth of our vegetables and animals." These are some of the songs, which God, the maker of us both, has given me in the night.

The influences of the Moon upon sublunary bodies, are very wonderful. A history of them is yet among the *desiderata* of our philosophy. With my consent, he shall merit more than the title of a Rabbi Solomon Jarchi, who gives it to us. Dr. Grew, in his Cosmologia, has enumerated more than a dozen remarkable heads of effects, motions and changes in the world, over which the Moon has a sensible dominion. Our lunatics are not the only instances. Our husbandmen will multiply instances upon us, till they make a volume, to which neither a Columella, nor a Tom Tusser have reached. The Georges of my neighbourhood just now furnish me with two instances, which have in them something that is notable. If our chesnut wood, whereof we sometimes make fuel, be cut while the Moon is waxing, it will so sparkle in the fire, that there shall be no

sitting by it in safety. If it be cut while the Moon is wanning, there will be no such inconvenience. Moreover, we find, whatever timber we cut, in two wanes of the Moon in a year, the wane in August, and the wane in February, will be for ever free from worms. What Andry relates, confirming the observation of Borellus, about the success of medicines for worms in human bodies, taken in the wane of the Moon, is wonderful.

"I am sure, to be under such influences of the Moon, as to see the great God managing many of his gracious intentions by such an instrument; and to be awakened to his praises in the night, when we see the Moon walking in her brightness; would not be a lunacy, of which the most rational of men could be ashamed."

ESSAY XII. *Of* RAIN.

WE are now coming down to our atmosphere. Here we are quickly surrounded with clouds. And here we quickly find ourselves in the midst of that rain, whereof the great God, in his book, so often claims the glory of being the Maker and giver.

The rain is water by the heat of the sun divided into very small and invisible parts; which ascending in the air, till it encounters with the cold, is by degrees condensed into clouds, and thence descends in drops. A mist is a multitude of little, but solid globules; which therefore descend. A cloud is a collection of little, but concave globules; which therefore ascend to that height, wherein they are of equal weight with the air, where they remain suspended, till by a motion in the air they are broken,—come down in drops;

either smaller, as in a mist; or bigger, when many of them run together, as in a rain.

Though the rain be much of it exhaled from the salt sea, yet by this natural distillation it is rendered fresh and drinkable to a degree, which hardly any artificial distillation has yet effected.

The clouds are so carried about by the winds, as to be so equally dispersed, that no part of the earth wants convenient showers, unless when it pleases God, for the punishment of a sinful people, to withhold rain, by a special interposition of his providence: or, if any land wants rain, they have a supply some other way; as in the land of Egypt, where little rain falls, there is an abundant recompense made for that want, by the annual overflowing of the Nile. Mr. Ray well observes, that this distribution proclaims the providence of God, and is from a divine disposition. Without this, there would be either desolating floods, or such droughts as that of Cyprus in which no rain fell for thirty years together, and the island was deserted, in the reign of Constantine. The gradual falling of the rain by drops, is an admirable accommodation to water the earth. It is the best way imaginable. If it should fall in a continual stream, like a river, every thing would be vastly incommoded with it.

When God gives rain from heaven, he will give also fruitful seasons in our minds, if they be thereby led to due acknowledgments of him. It will bespeak, it will procure, the richest showers of blessings upon us. "How seasonable will it be for us now humbly to acknowledge the witness which our God gives us of his power and goodness! To see the paths of God in the clouds

which drop fatness upon us! To wish for those influences of Heaven, which may come upon ourselves like rain upon the grass, as the showers that water the earth, and rain down righteousness upon the world! To resolve upon an imitation of our merciful God, who sends rain upon the just and the unjust! To send up our desires, that we may not be like the earth, which drinks in the rain that comes often upon it, but bears thorns and briers, rejected, and nigh unto cursing! In fine, to glorify our God with confessions of this importance; can the heavens give showers? Art not thou he, O Lord our God? Therefore we will wait upon thee; for thou hast made all of these things."

The archbishop of Cambray shall express our sentiments. "If I lift up my eyes, I perceive in the clouds that fly above us, a sort of hanging seas, that serve to temper the air, break the fiery rays of the Sun, and water the earth when it is too dry. What hand was able to hang over our heads those great reservatories of waters! What hand takes care never to let them fall, but in moderate showers!"

ESSAY XIII. *Of the* RAINBOW.

WE are called upon, to consider the wondrous works of God; and particularly that, wherein he causes the light of his cloud to shine, that is to say, his rainbow.

A famous clergyman of Spalato, in a book concerning the rays of light, and vision, written before the former century, began mathematically to describe how the interior bow of the iris is formed in round drops of rain, by a refraction of

the sun's light, and one reflection between them; and the exterior by two refractions, and two sorts of reflections between them, in each drop of water.

Des Cartes, who does not use to betray his tutors, took the hints from Antonius de Dominis, and went on mathematically, and with much demonstration, to give us a theory of the iris, from the laws of refraction, which lucid rays do suffer in passing through diaphanous bodies. He clearly demonstrated the primary iris to be only the sun's image, reflected from the concave surfaces of an innumerable quantity of small spherical drops of falling rain; with this necessary circumstance, that those rays which fell on the objects, parallel to each other, should not after one reflection, and two refractions, (to wit, as going into the drop, and coming out again) be dispersed or made to diverge, but came back again also to the eye, parallel to each other. The secondary iris, he supposes produced by those rays of the sun, which fall more obliquely, but after the same manner as before: only in these there are two reflections, before the sun's rays, refracted a second time, and tending towards the eye in a parallel position, can get out from the aqueous globules.

The acute and accurate Mr. Halley comes after the French philosopher, and shows how the Cartesian problems were more easily solved, than the author himself imagined. He shows how to determine the angle, by which the iris is distant from the opposite point of the sun; and the ratio of the refraction being given geometrically, or vice versa, the iris being given, to determine the refractive power of the liquor. And he goes on to cultivate the subject with the ingenuity proper to *so accomplished* a gentleman.

But then comes the admirable Sir Isaac Newton, whom we now venture to call the perpetual dictator of the learned world, in the principles of natural philosophy; and than whom, there has not yet shone among mankind a more sagacious reasoner upon the laws of nature. This rare person, in his incomparable treatise of Opticks, has explained the phenomena of the rainbow; and has not only shown how the bow is made, but how the colours whereof antiquity made but three, are formed; how the rays do strike our sense with the colours, in the order which is required by their degrees of refrangibility, in the progress from the inside of the bow to the outside: the violet, the indigo, the blue, the green, the yellow, the orange, and the red.

In a book entitled, Thaumantiadis Thaumasia, published at Norimberg, the skilful author lays together whatever is to be found upon this argument, among the modern, as well as the ancient writers.

It is good advice given by the son of Sirach; look upon the rainbow, and praise Him that made it. Frytschius says:

"When you discern the bow of heaven to rise,
The brightest meteor there salutes your eyes:
Producing various colours on the cloud,
Mankind behold it, and survives the flood.
Behold it, sirs, a sign of heavenly love,
And of a covenant made by God above:
Almighty God did by that sign engage
To keep his Noah's world from age to age.
'Tis thus engaged, God will no more employ
Deep waters, as of old, men to destroy."

The halo is of so near kindred to the rainbow, that it claims a mention with it: a circle that surrounds the sun, or the moon, or a star, is sometimes coloured like a rainbow. According to Sir

Isaac Newton, it arises from the sun's or moon's shining through a thin cloud, consisting of globules of hail or water, all of the same size. Mr. Huygens conceives it formed by small round grains of a kind of hail, made up of two parts; one of which is opaque, and inclosed in the other, which is transparent. The same way he accounts for the parhelia. Only there he apprehends, that the icy grains are of an oblong figure, and rounding at the ends like cylinders, with round convex tops. May we look upon the rainbow, and praise Him that made it! My readers, will you give me leave to teach you the use of the bow? Mercer tells us, the religious Jews in many places, upon the appearance of a rainbow, go forth and fall down, and confess their sins, and own themselves worthy to be drowned with a flood for them. To us Christians, our Lord says, what do you more than they? "As the sight of the rainbow should bring to remembrance, what a woeful, what a fearful desolation, once came upon a wicked world, whose foundation was overflown with a flood! So the sacramental importance, now instamped by the will of God upon the rainbow, should be acknowledged with us. It should be considered as a sign and a seal of a covenant, which the great God has made, that He will not have this world, though a sinful one, drowned any more, nor his church in the world. Upon the view of the admirable meteor, how proper this doxology; Blessed be our gracious, merciful, and long suffering Lord; who hath sworn, that the waters of Noah shall go over the earth no more! But then, how can we forget the glorious Christ, who is our head in the covenant; and about whose

head there has been the appearance of a rainbow, in the visions of his prophets, betokening our dependence upon Him for all our preservations! But then we are not excused from, but rather excited to these further thoughts on this occasion: That though a watery flood, which may drown the world, is no more to be feared; yet there is a fiery flood, for the depredations whereof, a miserable world is growing horribly combustible.

ESSAY XIV. *Of* SNOW.

OF snow there are many curiosities observed by the excellent Dr. Grew.

He observes, as well as Des Cartes, and Dr. Hook, that very many parts of the snow are of a most regular figure; they are generally so many rowels, or stars of six points, being as real, as perfect, as transparent ice, as any one may see upon a vessel of water: on each of which six points, there are set other collateral points, and those always at the same angles as are the main points themselves. These are of divers magnitudes; many are large and fair, but some are very minute.

Among these, there are found some irregular ones, which are but fragments of the regular. But some seem to have lost their original regularity, not by being broken, but by various winds, first gently thawed, and then froze into such irregular clumpers again. A snowy cloud seems then to be an infinite mass of icicles regularly figured, not so much as one of the many millions being irregular. A cloud of vapours is gathered into drops; the drops forthwith descend. On the descent they pass through a soft wind that freezes them,

or a cold region of the air, by which each drop is immediately froze into an icicle, that shoots forth into several points from the centre. But still continuing their descent, and meeting with some sprinkling little gales of a warmer air, or in their continual motion or waftage to and fro, touching upon each other; some are a little thawed, blunted, frosted, clumpered; others broken: but the most hanked and clung in several parcels together, which we call flakes of snow.

It should seem, that every drop of rain contains in it some spirituous particles. These meeting in the descent, with others of an acido-salinous nature, the spirituous parts are apprehended by them, and with those the watery; and so the whole drop is fixed, but still according to the energy of the spirituous, as the pencil, and the determinate possibility of the saline parts, as a ruler, into a little star.

Though the snow seem soft, yet it is truly hard; it is ice; but the softness of it is from this; upon the first touch of the finger on the sharp edges, it thaws immediately; the points would else pierce the fingers like so many lancets.

Again, though the snow be true ice, and so hard and so dense a body, yet it is very light: this is because of the extreme thinness of each icicle, in comparison of the breadth. As Gold, though the most ponderous of all bodies, beaten into leaves, rides on the least breath of air.

" When we see the snow, that comes down from heaven, and returns not thither, but waters the earth, and makes it bring forth and bud; we cannot but hope, that the word of our God, which comes like it, will continue with us, and accomplish the intentions of it.

" Whereof one, upon the soul of thy servant, O my God! is, to produce my desires, that my sins, which have been like scarlet, may become white like snow, in thy free and full pardon of them. O wash me in the blood of my Saviour, and I shall be whiter than snow! But Lord, let a work of real sanctification, at the same time upon me, render me purer than snow!"

ESSAY XV. *Of* HAIL.

HAIL is very often a concomitant of thunder and lightning. It is well known, as Dr. Wallis observes, that in our artificial congelation, a mixture of snow and nitre, or even common salt, will cause a very sudden congelation of water. Now the same in the clouds may cause hail stones; and the rather, because not only in some that are prodigiously great, but also in common hail stones, there seems to be something like snow, rather than ice, in the midst of them. The large hail stones, that weigh half or three quarters of a pound, by the violence of their fall manifest that they have descended from a considerable height. And though perhaps in their first concretion, their bulk might not exceed the moderate size of the common hail; yet in their long descent, if the medium through which they fell, were alike inclined to congelation, they might receive a great accession to their bulk, by perhaps many of them coalescing and incorporating into one.

Worse than Egyptians they, whom an hail storm will not cause to fear the word of the Lord. The irresistible judgments of God are sometimes compared to hail storms, and great hail stones. These things come down upon the world with

that voice, tremble to be in ill terms with a God, who with a tempest of hail, and a destroying storm, can immediately crush all that is opposed to him."

Of all the meteors both the fiery and the watery, the poet has well acknowledged;

> Who sees bright meteors in the liquid skies,
> Has the great works of God before his eyes.

ESSAY XVI. *Of* THUNDER & LIGHTNING.

HIS powerful thunder, who can understand? Yet our philosophy will a little try to see and say something of it.

The account of thunder, given by Dr. Hook, is this: The atmosphere of the earth abounds with nitrous particles of a spirituous nature, which are every where carried along with it. Besides which sort of particles, there are also others raised up into the air, which may be somewhat of the nature of sulphureous, unctious, and other combustible bodies. We see spirits of wine, turpentine, camphire, and almost all other combustible bodies, will by heat be rarefied into the form of air, or smoke, and be raised up into the air. All these, if they have a sufficient degree of heat, will catch fire, and be turned into flame, from the nitrous parts of the air mixing with them; as it has been proved by thousands of experiments. There are also other sorts of such steams, that arise from subterraneous and mineral bodies; which only by their coming to mix with the nitre of the air, though they have no sensible heat in them, will so ferment and act upon one another, as to produce an actual flame. Of this, the miners are too frequent witnesses and

sufferers. The lightning seems to be very much of such an original.

Dr. Wallis observes, that thunder and lightning have so much resemblance to fired gunpowder in their effects, that we may very well suppose much of the same causes. The principal ingredients in gunpowder, are nitre and sulphur. Suppose in the air, a convenient mixture of nitrous and sulphureous vapours, and those to take fire by accident, such an explosion, and with such noise and light as that in the firing of gunpowder, may well follow upon it; and being once kindled, it will run from place to place, as the vapour leads it, like as in a train of gunpowder. This explosion, high in the air, and far from us, will do no considerable mischief. But if it be very near us, it has terrible consequences. The distance of its place may be estimated by the distance of the time, which there is between seeing the flash, and hearing the clap: for though in their generation they be simultaneous, yet light moving faster than sound, they come successively to us. That there is a nitrous vapour in it, we may reasonably judge, because we know of no other body so liable to so sudden and furious explosion. That there is a sulphureous one, is manifest from the smell that attends it, and the sultry heat, that is commonly a forerunner of it.

"The natural causes of the thunder do not at all release me from considering the interest and providence of the glorious God, concerned in it. It is a note prepared for the songs of the faithful, the God of glory thundereth. And indeed, as the thunder is the voice of God, (Paganism itself owned as such) thus there are several points of

piety, wherein I am, as with a bath kol, instructed from it.

"There is this voice most sensibly to be heard in the thunder, power belongeth unto God. There is nothing able to stand before those lightnings, which are styled the arrows of God. We see castles fall, metals melt, bricks themselves vitrify; all flies, when hot thunderbolts are scattered upon them. The very mountains are torn to pieces by their force. The thunder of his power who can understand? An haughty emperor shrinks, shakes, and hides his guilty head, before the powerful thunder of God.

"How can I hear the voice of the Almighty thunderer, without such thoughts as these? Glorious God, let me through the blood of a sacrificed Saviour, be in good terms with one so able to destroy me in a moment! and let me be afraid of offending Him, who is possessed of such an irresistible artillery!

"At the same time, do I not see the mercy and patience of a good God to a sinful world? The desolations of the world, how wonderfully would they be, if every transgression met with its just reward!

"It is no rare thing for the children of men to die by a thunderbolt: a king has been so slain in the midst of his army. There was a punishment of old used upon criminals, by pouring hot lead into their mouths, and used in imitation of God's destroying with lightning; whereby the inward parts are burnt without any visible touch upon the outward. This death by lightning, has been frequently inflicted. Their being asleep at the time has not preserved them, though there be a

fancy in Plutarch that it would; nor would a tent of seal skin have done it, though some great ones have repaired to such an amulet for their protection. My God, I adore thy sovereign grace, that such a sinner as I, have not yet been by lightning turned into dust and ashes before thee!

"I take notice of one thing, that as guilt lying on the minds of men, makes them startle at a thunder clap; so the miscarriages about which our hearts do first and most of all misgive us in a thunder storm, are those which most of all call for a thorough repentance. There are some writings which I cannot read, except I hold them against the fire; by having my heart held up against the lightning, I may quickly read my own iniquity."

"Impious people are deaf to thunder!"

Herlicius, in his Tractatus de Fulmine, reckons up a considerable number of those, which might be called Fælicia Fulmina. Such will they be that made these impressions upon us.

ESSAY XVII. *Of the* AIR.

THE air of our atmosphere in which we breathe, is a diaphanous, compressible, dilatable fluid; a body covering the earth and the sea, to a great height above the highest mountains.

There seem to be three different sorts of corpuscles, whereof the air is composed. There are such as are carried up into the air from other bodies, as vapours exhaled by heat. There may be also a more subtile kind, mixed with our air, emitted from the heavenly bodies, and from the magnetic steams of the globe on which we sojourn. But there may be a third sort of particles, which may most properly merit the name of

ærial, as being the distinguishing parts of the air, taken in the stricter sense of the term. These particles have an elasticity resembling the spring of a watch. Elasticity is an essential property of the air, and it is thought no other fluid has any thing of it, only as it participates of air, or has air contained in the pores of it. Our air abounds with particles which being pressed by the weight of the incumbent atmosphere, or any other body, endeavour to free themselves from that pressure, by bearing against the bodies that keep them under it; and as soon as the removal of these bodies gives them way, they expand the whole parcel of air which they composed.

Mr. Boyle found, that one and the same portion of air may take up 52,000 times the space it doth at another time. He found, that the same quantity of air, by only having the pressure of the atmosphere taken off in the pneumatic engine, and without increasing the spring with any adventitious heat, would possess above 13,000 times its natural dimensions. Dr. Gregory proceeds, That accordingly a globe of air, of one inch diameter, would at the distance of the semidameter of the earth from the earth, fill all the planetary regions much beyond the sphere of Saturn. Admirable rarefaction!

The weight of air was discovered first by Galilæus, who found that water could not by pumping be raised higher that 34 or 35 feet. Torricellius afterwards pursued and improved the thought, and as a further proof of the weight of the air, invented that which we call the Torricellian experiment. Mr. Boyle found by repeated experiments, that the weight of air to water is as 1 to *1000.*

Dr. Halley rather determines the specific gravity of air to water, to be about 1 to 800. Mercury is to air as 10,800 to 1. And so, a cylinder of air, of 900 feet, is equal to an inch of mercury.

We will, with Dr. Wainwright suppose a cubical foot of water to weigh 76 pounds troy weight. The compass of a foot square upon the superficies of our bodies, must sustain a quantity of air, equal to 2610 pounds weight. If the superfices of a man's body contains fifteen square feet, which is pretty near the truth, he will sustain a weight equal to 39,900 pounds troy. The difference between the greatest and the least pressure of the air upon our bodies, is equal to 3982 pounds troy. On which the doctor says, "No wonder then we suffer in our health by change of weather; it is surprising that every such change does not entirely break the frame of our bodies to pieces, and be the constant harbinger of sudden death." My God, it is because I have obtained help from thee, that I continue to this day!

Sir Isaac Newton thinks true and permanent air to be made by fermentation and rarefaction of bodies that are of a very fixed nature. And it is plain, those particles fly and avoid one another with the greatest force at a distance, which when they are very near, do attract and adhere with the greatest violence.

The particles of true and permanent air, being extracted from the densest and most fixed bodies, will be more dense and crass than those of vapour, and the parts of a humid atmosphere may be lighter than those of a dry one, as in fact they appear to be. He thinks therefore, that the rarefaction and condensation of the air cannot be ac-

counted for from the spring, or elastic forms of the particles, without a supposition that they are endued with some centrifugal force or power, by which they fly and avoid one another, and the dense bodies from which they are extracted.

This may be the cause for ascent of water in small capillary tubes, to a much greater height than the surface of the water in the open vessel in which they are placed. The air within the tubes is much rarer than in more open spaces, and presses less on the surface of the water within the tubes than without.

It is admirable to consider the necessity of air to the whole animal world; how soon the vital flame languishes and expires if air be withheld from it! even the inhabitants of the water cannot live without it. It is evident the air easily penetrates water exposed to it, and diffuses itself through every part of it. Put fishes into a vessel of a narrow mouth, full of water, they will continue to live and swim there whole months and years. But stop the vessel, so as to exclude the air, they will suddenly be suffocated; an experiment often made by Rondeletius. Insects need more air than other creatures, having more air vessels for their bulk, and many orifices on each side of their bodies for its admission, which if you stop with oil or honey, they presently die. Malpighius has discovered and demonstrated, that the plants themselves have a kind of respiration, being furnished with vessels for the derivation of air to all their parts. Dr. Hulse, and Mr. Ray, and others, have now also rendered it very evident, that the fætus in the womb receive a measure of air from the maternal blood, by the *placenta uterina*,

or the cotyledons. When this communication is broken off, what is it that now, to preserve the life of the animal, speedily raises the lungs, and fetches into them an abundance of air, which causes a sudden and mighty ascension in the blood, for the maintenance whereof a far greater quantity of air is requisite? Certainly some intelligent being must now interpose, to put the diaphragm, and all the muscles that serve to respiration, into their motion! My God I know thee! And now, as our ingenious Waller sings;

> "Thus wing'd with praise, we penetrate sky,
> Teach clouds and stars to praise him as we fly.
> For that he reigns, all creatures should rejoice,
> And we with songs supply their want of voice.
> Angels and we, assisted by this art,
> May sing together though we dwell apart."

"The Syrians worshipped the air as a god. I will worship him that created it. I will give thanks to the glorious God, for the benefits with which the air is replenished by his bounty. It was long since called the paranymph, by which the espousal and communion between heaven and earth is carried on. I breathe in the favours of God continually. An ungrateful wretch, if I do not breathe out his praises! How justly might the great God fill the air with such pestilential poisons, as might suffer the unholy and unthankful to breathe no longer in it!"

ESSAY XVIII. *Of* WIND.

WHAT better definition of wind, than a stream of the air? Plato long since defined it, the motion of the air about the earth. Other hypotheses for this current of the air not well answering all phenomena, the learned Mr. Halley recommends this to

consideration, as the cause of it; the action of the sunbeams on the air and water, as the sun passes every day over the oceans, considered with the nature of the soil, and the situation of the continents adjoining.

According to the laws of statics, the air, which is less rarefied and expanded by heat, and consequently more ponderous, must have a motion round those parts thereof, which are more rarefied and less ponderous, to bring it to an equilibrium. The presence of the sun also continually shifting to the westward, that part to which the air tends, by reason of the rarefaction made by his greatest meridian heat, is with him carried westward, and consequently the tendency of the whole body of the lower air is that way. Thus a general easterly wind is formed. From this principle, the easterly wind on the north side of the equator, should be to the northward of the east; and in south latitudes, it should be to the southward thereof: inasmuch as near the line, the air is more rarefied than at a greater distance from it. Here all the phenomena of the general trade winds are answered for; which if the whole surface of the globe were sea, would undoubtedly blow all round the world, as they are found to do in the Atlantic and Ethiopic oceans. But since great continents interpose, and break the continuity of the oceans, regard must be had to the nature of the soil, and the position of the high mountains, which cause the variation of the winds, from the general rule that has been proposed. If a country, which lies near the sun, prove to be low, flat and sandy, the heat occasioned by the reflection and retention of the sunbeams there, will so rarefy the air, that

the denser and cooler air will run thither, to restore the equilibrium. Hence may be the constant calms in that part of the ocean, called *the rains*. This tract being placed in the middle, between the westerly winds blowing on the hot coast, and the easterly winds that blow to the westward, the tendency of the air there is indifferent to either, and so stands in equilibrium, between both; and the weight of the incumbent atmosphere being diminished by the continual contrary winds blowing from hence, the air here holds not the copious vapour it receives, but lets it fall into frequent rains.

It is very hard to conceive, why the limits of the trade wind should be fixed about the thirtieth degree of latitude all round the globe, and that they should so seldom transgress those bounds, or fall short of them. Behold the wings of the wind.

The inquisitive and ingenious Mr. Derham found by many trials, that the wind in a great storm does move about fifty or sixty miles in an hour; that a common brisk wind moves about fifteen miles an hour. But so gentle is the course of many winds, that they do not exceed one mile an hour.

Dr. Grew observes, that there are winds (besides the trade winds) especially from the west, which blow sometimes two or three days upon one point, and will in this time drive before them a ship an hundred and fifty leagues, or four hundred and fifty English miles.

Wind is of great use to ventilate the air, and to dissipate contagious vapours; which if they should stagnate, would produce grievous diseases on the animal world. It also transfers the clouds from one place to another, for the more commodious

watering of the earth. It likewise tempers the heat of many countries, which else would be excessive. It carries vessels on their voyages to remote countries. Windmills are driven by it, whereof there are many benefits. But as the excellent Mr. Ray observes, that it is rarely so violent, as to destroy all before it, and overwhelm the world; this proclaims a superior power moderating it, the wisdom and goodness of Him, who brings the wind out of his treasures.

What amazing things the winds called the Typhons, and how irresistibly furious! But our merciful God stays the rough winds.

The hurricanes in the West Indies, and their brethren the monsoons in the east; what shocking stories do travellers relate of them! how direful effects are sometimes caused by them! They blow down mighty trees by the roots. They chase mighty ships up into the woods. They make every thing to tremble, and give way, that opposes them. Great God, who ridest on the wind, and makest it move which way thou shalt please; who can stand in thy sight if thou art angry!

Whatever point of the compass the wind blows upon, it may blow some good thoughts into our minds; and then it will be no ill wind to us.

"We ought certainly to consider the stormy wind, as fulfilling the word of God. And there are tempests, and whirlwinds of the divine wrath to be deprecated. But then there are influences of heaven to be desired, which are, As the wind bloweth where it listeth, and we hear the sound thereof, but cannot tell whence it cometh, nor whither it goeth."

ESSAY XIX. *Of* COLD.

THERE is much dispute about the first cause of cold. It is questioned by some whether the cold be any thing positive, and not a mere privation. The coldness of any thing, they say, signifies no more, than its not having its insensible parts agitated so much as those of our sensories, by which we judge of tactile qualities. To make a thing become cold, there needs no more, than that the sun, or fire, or some other agent, that more vehemently agitated its parts before, do now cease to do it.

But then, on the other side, there are instances of cold produced by vehement agitations.

To some there seems to be a mighty store of corpuscles, a little akin to nitre, exhaled from the terrestrial globe, (of the figure of which Philoponus tells us, Democritus assigned to frigorific atoms) which may more than a little contribute to our cold.

That cold (and so freezing) may arise from some saline substance floating in the air, seems probable from this; that all salts, but some above others, when mixed with snow or ice, do prodigiously increase the force of cold. And all saline bodies produce a stiffness in the parts of those bodies, into which they enter.

The force of cold is truly wonderful. Olearius tells us, in Muscovy spittle will freeze before it reach the ground. So violent the cold there, that no furs can hinder it, but sometimes the noses, the ears, the hands, and the feet of men will be frozen, and all fall off. It is reported by Fletcher and Herberstein, that not only they who travel abroad, but many in the very markets of their towns are *so mortally pinched* as to fall down dead with

cold. Capt. James and Gerat de Veer tell us frightful things of the cold they found in their northern coasting. Beauplan adds, that without good precautions, cold produces those cancers, which in a few hours destroy the parts they seize upon. What mighty rands of ice have been encountered by such navigators as Munchius and Baffin, who found some icy islands near three hundred feet high above the water! In the river of Canada sometimes are seen icy islands, computed fourscore leagues in length.

The irresistible force of congelation!—Congelation seems to be from the introduction of the frigorific particles, into the interstices between the particles of the water; and thereby getting so near to them, as to be just within the sphere of each other's attracting force, on which they cohere into one solid body.

The dimensions of water are increased by freezing; and with such a force in the expansion, that the weights raised by it, the stones broke in it, the metals obliged to give way to it, were hardly credible, if these eyes had not seen them!

"When we consider the cold, especially if we have it under our more sensible consideration, we cannot but subscribe to that word, who can stand before his cold! How naturally are we now led to a dread, and a deprecation of lying under the displeasure of the glorious God, who by that one part of his artillery, the cold alone, can soon destroy his enemies!"

The mitigations of our cold, and our comforts and supports against the assaults of it, bespeak our thankful praises to our glorious Benefactor: That we are not, as Livy says of the Alps, condemned *to eternal* snows!

It is observable, that the degrees of cold in several climates are not according to their degrees of latitude. Some have met with very tolerable weather under the Arctick pole. In the north of China, for four months in the year, the rivers there are so frozen, that the ice will bear the passage not only of men, but of horses and coaches upon it. The like report could I give of my own country, which lies in the same latitude. In my warm study, from the billets of wood lying on a great fire, the sap forced out at the ends of the short billets by the fire, has frozen there, and been turned into ice, while the wood has been consuming. However, our cold is much moderated since the opening and clearing of our woods, and the winds do not blow roughly, as in the days of our fathers, when water, cast up into the air, would commonly be turned into ice before it came to the ground.

ESSAY XX. *Of the Terraqueous* GLOBE.

THE distance at which our globe is placed from the Sun, and the contemperation of our bodies and other things to this distance, are evident works of our glorious God.

According to the accurate observations of the English Norwood, and the French Picart, the ambit of our globe will be twenty-four thousand nine hundred and thirty miles. Wherefore supposing it spherical, the whole surface will be 197,831,392 miles; which in the solid content will be found no less than 261,631,995,920 miles. The cubic feet will be 30,000,000,000,000,000,000,000. The earth, with her satellite, the moon, moves about the sun, according to Derham, in an

orbit of more than 540 millions of miles in circumference, or 172 millions of miles in breadth.

The Copernican hypothesis is now generally preferred, which allows a diurnal and an annual motion to our globe, rather than to the sun. According to this, the diurnal motion of our globe is near 1,039 miles in an hour.

The arguments that prove the stability of the sun, and the motion of the earth, have now rendered it indisputable. It is impossible to account for the appearances of the planets, and their satellites, and the fixed stars, in any tolerable manner, without admitting the motion of the earth; or to account for comets; or for that analogy of the periodical times, to the middle distances, which is the necessary consequence of the established law of gravitation. Unless we would subvert the whole system of astronomy, and disprove the causes of all the celestial motions, we shall never be able to assert, that the earth stands unmoved. Nor is there any objection against the motion of the earth, but what has had a full solution.

How much these motions performed so regularly for near six thousand years, oblige us to cry out, great God, thou that art the Creator, art also the Governor of the world!

The prophet Habakkuk mentions the stop to this course in the days of Joshua, as a real matter of fact. The same infinite Power that gave the motion, gave the check.

The circumvolutions of the globe are of admirable convenience, yea, of absolute necessity to the inhabitants.

The spherical figure of our globe has numerous and marvellous conveniences, whereof no man

that seriously considers it can be insensible. How incommodious must an angular figure have been; or such an one as many of the ancients, and particularly the Epicureans, with stupidity enough imagined?

It is admirably well ordered, that the axis of the globe should be steady, and perpetually parallel to itself; not carlessly tumbling this way and that way, as it might happen; and that the posture of the axis be inclining as it is, and not perpendicular to a plane going through the centre of the sun, or coincident. Hence comes the globe to be so habitable in all parts; and even under the line itself, as it is noted by Sir Walter Raleigh, the parts are as pleasant, and as fruitful, and as fit for a paradise, as any in the world. And the longevity of the natives there does rather exceed the rest of mankind, as we learn from the relations of Piso, and Rochefort, and Pirard, and le Blanc, and other testimonies. Yea, Mr. Keill demonstrates, that from the present position of the globe, and the inclination of its axis to the plane of the ecliptic, we reap this advantage; they who live beyond forty-five degrees of latitude, and have most need of it, have more of the heat of the sun throughout the year, than if he had shined always in the equator: whereas in the torrid zone, and even in the temperate, almost as far as forty five, the sum of the sun's heat, in summer and winter, is less than it would be, if the axis of the globe were perpendicular to the plane of the ecliptic. He very well adds, this consideration cannot but lead us into a transcendent admiration of the divine Wisdom! Yea, were the whole creation surveyed, it would be every where found, as Mr. Ray ob-

serves, that God has chosen better for us, than we could have done for ourselves.

The collection of the waters on the globe into such vast conceptacle, wherein the innumerable fishes are nourished, and whereon voyages are performed; and the distinction of the dry land, furnished with so many vegetables and animals: what can it be any other than the result of counsel, of design, of infinite wisdom! How blind art thou, O man, and under what a brutal and fatal darkness, if thou see it not! the brutish among the people will not be wise.

The figure of our globe is most probably that of an oblate spheroid. It swells towards the equatorial parts, and flats towards the polar; according to Sir Isaac Newton, the diameter of the globe is about thirty four miles longer than the axis.

Dr. Gregory shews, that this is the reason why the axis of our globe does twice every year change its inclination to the ecliptic, and as often return back again to its former position.

That most accurate astronomer, Mr. Flamstead, found the distance of the pole star from the pole, to be greater about the summer solstice than about the winter, by about forty or forty five seconds. He found also by repeated observations, a sensible annual parallax in others of the fixed stars. This proves our globe to move annually about the sun.

Mr. Halley shows the annual motion of the earth to be so swift, as far to exceed that of a bullet shot out of a cannon, and to be after the rate of 210 miles in a minute, and 12,600 miles in an hour.

Our globe is nearer to the sun in December

than in June. Its perihelion is in December. The sun's apparent diameter is greater then; and our globe then has a swifter motion by a twenty fifth part. Hence there are about eight days more in the summer half year, than in the winter half year. The colder and more northern places of our globe are indeed brought some hundreds of thousands of miles nearer the sun in winter than in summer.

Upon the Occurrences of the whole GLOBE.

O MAN! we are now come down into thy territories. How many servants may man here see himself attended and surrounded with! the most reasonable thing in the world is for man hereupon to contrive and resolve in this manner; O that my service to the glorious God may be as obedient, as willing, as ready, as what his creatures yield to me!

"But then to this we will annex a further disposition of piety: can a man be profitable to God? my service to Him does not advantage Him. When I have done all, I am an unprofitable servant. Wherefore let me study to transfer to my neighbour, the service which by the creatures of God is done to me. Yea, let me as far as I can labour to do to my neighbour such things as the great God pleases to do to me. In this charity, there will be that image of the glorious God, which is the glory of the man that arrives to it.

"Man, let the glorious God have praises from thee, and have thy homage and service. Hereby the creatures will be returned and united to God their maker, and it will be brought about, that they shall not be made in vain.

"There is another pathetic remark, made more than an hundred years ago, but worthy to be for ever thought upon; every creature, but only the wicked sinner, loves God more than it loves itself."

As we go along, we cannot well avoid speaking of cohesion. We see two very plain, smooth, well polished bodies, will firmly cohere, even in an exhausted receiver. This renders it evident, that cohesion is not owing to the gravity, nor to any other property of the air. What appears in the surfaces of cohering bodies upon their breaking, shows us, that a necessary condition of cohesion is a congruity of surfaces; and such as excludes any fluid from lying between them. We may suppose, with Dr. Cheyne, that some of the primary atoms, whereof bodies are constituted, are terminated with plain and smooth surfaces on all sides; which will produce bodies of the strongest cohesion: others are partly terminated with plain and smooth, and partly with curve surfaces, which will produce bodies of a meaner cohesion. Others are entirely terminated with curve surfaces, which will produce fluids, and between these entirely plain and smooth, and entirely curve, there are infinite combinations of surfaces, plain, and smooth, and curve, which will account for all the various degrees of cohesion in bodies, in respect of their figures. But now the cement, which hinders the separation of bodies, when the points of their surfaces are brought into contact; this, can be nothing but the universal law of attraction, whereby all the parts of matter endeavour to embrace one another, and cannot be separated but by a force, that shall be superior to that by which they attract.

"Being arrived here, we are gotten within a little of the glorious God. The very next step we take must be into Him, who is the immediate cause of weight in matter. None but He producing, imprinting, preserving that property in matter, is to be now considered. We will go on to take notice of that property."

ESSAY XXI. *Of* GRAVITY.

To our globe there is one property so exceedingly and so generally subservient, that a very great notice is due to it; that is, gravity, or the tendency of bodies to the centre.

A most noble contrivance to keep the several globes of the universe from shattering to pieces, as they would else evidently do in a little time, through their swift rotation round their own axis. Our globe in particular, which revolves at the rate of above a thousand miles an hour, would, by the contrifugal force of that motion, be soon dissipated, into the circumambient space, were it not kept well together by this wondrous contrivance of the Creator, gravity, or the power of attraction. By this power also, all the parts of the globe are kept in their proper place and order; all bodies gravitating thereto unite themselves with, and preserve the bulk of them entire; and the fleeting waters are kept in their constant equipoise, remaining in the place which God has founded for them, a bound which He hath set, that they may not pass, that they turn not again to cover the earth. It is by the virtue of this glorious contrivanee of the great God, who formed all things, that the observation of the Psalmist is perpetually fulfilled: thou rulest the raging of the

sea; when the waves thereof arise, thou stillest them.

Very various have been the sentiments of the curious, what cause there should be assigned for this great and catholic affection of matter, the vis centripeta: I shall wave them all, and bury them in the place of silence, with the materia striata of Des Cartes, which our Keil has very sufficiently brought to nothing; and perhaps the fluid of Dr. Hook must go the same way. It is enough to me what that incomparable mathematician, Dr. Halley, has declared upon it: that after all, gravity is an effect insolvable by any philosophical hypothesis; it must be religiously resolved into the immediate will of our most wise Creator, who by appointing this law, throughout the material world, keeps all bodies in their proper places and stations, which without it would soon fall to pieces, and be utterly destroyed.

All bodies descend still towards a point, which either is, or lies near to, the centre of the globe. Should our Almighty God change that centre but the two thousandth part of the radius of our globe, the tops of our highest mountains would be soon laid under water.

In all places equi distant from the centre of our globe, the force of gravity is nearly equal. Indeed, as it has been proved by Sir Isaac Newton, the equatorial parts are something higher than the polar parts; the difference between the earth's diameter and axis being about thirty four English miles.

Gravity equally effects all bodies. The absolute gravity of all is the same. Abstracting from the resistance of the medium, the most compact

and the most diffuse, the greatest and the smallest, would descend an equal space in an equal time. In an exhausted receiver a feather will descend as fast as a pound of lead. But this resistance of the medium has produced a comparative gravity. And upon the difference of specific gravity in many bodies, the observations of our philosophers have been very curious.

According to the exquisite Halley and Huygens, the descent of heavy bodies is after the rate of about sixteen feet in one second of time.

Nevertheless this power increases as you descend to, decreases as you ascend from the centre of the globe, and that in proportion to the squares of the distances therefrom reciprocally; as, for instance, at a double distance to have but a quarter of the force. A ton weight on the surface of the earth, raised heaven-wards to the height of one semidiameter of the earth from hence, would weigh but one quarter of a ton. At three semidiameters from the surface of the earth, it would be as easy for a man to carry a ton, as here to carry little more than an hundred pounds. At the distance of the moon, which suppose to be sixty semidiameters of the earth, 3600 pounds weight but one pound; and the fall of bodies is but sixteen feet in a whole minute.

I remember I have somewhere met with such a devout improvement of this observation: "The further you fly towards heaven, the more (if I may use the Falconers word) you must lessen. There is great reason why it should be so. Defamations particularly will be things by which you must be lessened: you must meet with heavy things; defamations are in a singular manner such; they

are not easy to carry; it is not easy to carry it well under them; some of them are a ton weight. But my friend, if you were as near heaven as you ought to be, you would make light of them; you would bear them wonderfully!"

The acute Borelli has demonstrated that there is no such thing as positive levity, and that levity is only a lesser degree of gravity. But how useful is this, not only to divers tribes of animals, but also to the raising up of the many vapours, which are to be conveyed about the world? The evaporations, which, according to Mr. Sedileau's observations, and others, are the fewest in the winter, and greatest in the summer, the most of all in windy weather, and considerably exceed what falls in rain, many being tumbled about and spent by the winds, and many falling down in dews.

The ingenious Halley has yet a suspicion that there may be some certain matter, which may have a conatus directly contrary to that of gravity; as in vegetation the sprouts directly tend against the perpendicular.

Dr. Gregory demonstrates, that the ancient astronomers were not ignorant of the heavenly bodies gravitating towards one another, and being preserved in their orbits by the force of gravity.

Mr. Keil shews, that the force of gravity to the centrifugal force, in a body placed at the equator of our globe, is as 289, to 1; so that by the centrifugal force arising from the earth's rotation, any body placed in the equator loses a 289th part of the weight it would have if the globe were at rest. And since there is no centrifugal force at the poles, a body there weighs 289 pounds, which at the equator would weigh but 288. On our globe

the decrease of gravity, in going from the poles towards the equator, is always as the square of the cosine of the latitude.

Mr. Samuel Clark observes, it is now evident that the most universal principle of gravitation, the spring of almost all the great and regular inanimate motions in the world, answering not at all to the surfaces of bodies, by which alone they can act one upon another, but entirely to their solid content; cannot possibly be the result of any motion originally impressed on matter, but must of necessity be caused by something which penetrates the very substance of all bodies, and continually puts forth in them a force or power entirely different from that by which matter acts on matter. This (he adds) is an evident demonstration, not only of the world's being made originally by a supreme intelligent cause, but moreover that it depends every moment on some superior Being, for the preservation of its frame, and that all the great motions in it are caused by some immaterial power, not having originaliy impressed a certain quantity of motion upon matter, but perpetually and actually exerting itself every moment in every part of the world: which preserving and governing power gives a very noble idea of Providence.

Dr. Cheyne demonstrates, that gravity, or the attraction of bodies towards one another, cannot be mechanically accounted for. The planets themselves cannot continue their motions in their orbs without it. It is not a result from the nature of matter, because the efficacy of matter is communicated by immediate contact, and it can by no means act at a distance. Whereas this power of gravitation acts at all distances, without any me-

dium or instrument for the conveyance of it, and passes as far as the limits of the universe. Matter is indeed entirely passive, and cannot either tend or draw, with regard to other bodies, no more than it can move itself. And what is essential to matter cannot be intended or remitted; but gravity increases or diminishes reciprocally, as the squares of the distances are increased or diminished. It is plain this universal force of gravitation is the effect of the divine power and virtue, by which the operations of all material agents are preserved. They that press for a mechanical account of gravity, advance a notion of a subtile fluid, unto the motion whereof they would ascribe it. But then still those parts of matter must be destitute of gravity, which were very unlikely! And this hypothesis would still remove us but one step further from immechanical principles; for the cause of the motion of your subtile fluid, this, gentlemen, you must own to be immechanical. Since you must admit a first cause, you had as good admit it in this place. It is He who does immediately impress on matter this property. There never was yet afforded unto the world (as my doctor observes) a system of natural philosophy which did not require postulates, that are not mechanically to be accounted for. The fewest any one pretends to, are, the existence of matter, and the impression of rectilinear motions, and the preservation of the faculties of natural agents. No man has pretended to fetch from the principles of mechanism an account for these. The impression of an attractive faculty upon matter, is no harder a postulate than the rest. It is a matter of fact, that matter is in possession of this quality.

And it can be referred to nothing, but the influence of that glorious One, who is the first cause of all things.

"Behold, a continual opportunity for a considerate and religious man, to have a sense of a glorious God awakened in him! and what is a walk with God, but that sense kept alive in every step of our walk? I am continually entertained with weighty body, or matter tending to the centre of gravity; I feel it in my own. The cause of this tendency, it is the glorious God. Great God, thou givest this matter such a tendency, and thou keepest it in its operation. There is no other cause but the will and work of the glorious God. I am now effectually convinced of that ancient confession, and must with affection make it, He is not far from every one of us. When I see any thing moving or settling that way that its heavy nature carries it, I may very justly think, and I would often form the thought, it is the glorious God, who now carries this matter such a way! When matter sinks downward, my spirit shall even therefore mount upward, in acknowledgment of the God who orders it. I will no longer complain, Behold, I go forward, but He is not there, and backward, but I cannot perceive him; on the left hand, where He doth work, but I cannot behold Him; He hideth himself on the right hand that I cannot see Him. No, I am now taught where to meet with Him even at every turn. He knows the way that I take. I cannot stir forward or backward, but I perceive him in the weight of every matter; on the left hand and on the right I see him at work. My way shall be to improve this as a weighty argument for the being of a God. I will argue from

it, Behold, there is a God, whom I ought for ever to love, serve, and glorify. Yea, and if I am tempted to the doing of any wicked thing, I may reflect that it cannot be done without some action wherein the weight of matter operates. But then I may carry on the reflection, How near am I to that glorious God, whose commands I am going to violate! Matter keeps his laws; but, O my soul, wilt thou break them? How shall I do this wickedness, and therein deny the God, who not only is above, but also is most sensibly now exerting his power in the very matter, upon which I make my criminal misapplications!"

Before we go any further, it appears high time to introduce an assertion or two of that excellent philosopher Dr. Cheyne, in his philosophical principles of natural religion. He asserts, and with demonstration, (for truly without this he asserts nothing!) that there is no such thing as an universal soul, animating the vast system of the world, according to Plato; nor any substantial forms, according to Aristotle; or any omniscient radical heat, according to Hippocrates; nor any plastic virtue, according to Scaliger; nor any hylarchic principle, according to More. These are mere allegorical terms, coined on purpose to conceal the ignorance of the authors, and keep up their credit with the credulous part of mankind. These unintelligible beings are derogatory from the wisdom and power of the great God, who can easily govern the machine he could create, by more direct methods than employing such subservient divinities; and indeed these beings will not serve the design for which we invent them, unless we endow them with faculties above the dignity of secondary *agents.* It is now plain from the most evident

principles, that the great God not only has the springs of this immense machine, and all the several parts of it, in his own hand, and is the first mover; but that without his continual influence the whole movement would soon fall to pieces. Yet besides this, he has reserved to himself the power of dispensing with these laws whenever he pleases.

My doctor has made it evident, that it is not essential to matter to be either in rest or in motion; but though there is in matter a vis inertiæ, by which all bodies resist, to the utmost of their power, any change of their state, whether of rest or motion; yet this vis is not essential to matter, but a positive faculty implanted therein by the Author of nature. It is therefore evident that the preservation of a body in rest or in motion, after the first instant, absolutely depends on the almighty God, as the cause. No part of matter can move itself, nor when put into motion, is this motion absolutely essential to its being, nor does depend upon itself; and therefore the preservation of this motion must have its dependence on some other cause. But there is no other cause assignable besides the omnipotent cause, who preserves the being and faculties of all natural agents.

Great God, on the behalf of all thy creatures, I acknowledge in thee we move and have our being!

ESSAY XXII. *Of the* WATER.

PURE water is a fluid void of all sapor, and seems to consist of small, smooth, round and porous particles, that are of equal diameters and equal gravities. There are also between them spaces, that are so large, and ranged in such a manner, as

to be on all sides pervious. Their smoothness accounts for their sliding easily over the surfaces of one another. Their roundness keeps them from touching one another in more points than one. So great is their porosity, that there is at least forty times as much space as matter in water. For water is nineteen times specifically lighter than gold; but gold will by pressure let water through its pores, and has doubtless more pores than solid parts.

Dr. Wainwright observes, the compounding particles of water are less than those of air; the former will pass through several bodies that the latter will not; it will force itself through the skins of animals, even after they are dried and converted into leather. Fasten a strong rope, of what length you please, to a hook; at the bottom of the cord hang any weight short of what will break it, though ever so great; you will find the weight will rise in moist weather, and sink in dry. You may also raise the weight, by moistening the sides of the cord with a wet sponge. Thus a few particles of water may overcome any finite resistance, if a cord will bear it. Now since there is but a little quantity of water in this experiment, and this is driven into the sides of the cord with a force no greater than the weight of a cylinder of air incumbent on the water, therefore the water must act by a property, whereby its force is greatly augmented; and this can be no other than that of the cuneus: and the forces of wedges are to one another reciprocally proportional to the angles their edges do make. But in spheres the greater or lesser degree of curvity is to be considered as their angles, when spheres are considered as wedg-

es, and the degrees of curvity in spheres are reciprocally as their radii. Now the particles of water being so inconceivably small, much less than those of air, they must, when acting as wedges, have their powers inconceivably increased, so as to overcome any finite resistance.

If such power is in a particle of water, what is thy power, O thou infinite Maker of that, and all things!

Dr. Cheyne observes, that the quantity of water on the outside of our globe doth daily decrease, part of it being every day turned into mineral, vegetable, and animal substances, which are not easily dissolved again into their component parts.

It is a curiosity demonstrated by Mariotte, in his du Movement des Eaux, that a Jet-d'eau never will rise as high as its reservatory, but always fall short of it by a space, which is the subduplicate ratio of that height.

In the congregations of water, and the distributions of it over our globe, we cannot but see the wonderful wisdom and goodness of our God. The great and wide sea, wherein are swimming things innumerable, it is full of thy riches, O our God! and the uses of it are marvellous. The waters are in the place which thou, O our God, hast prepared for them: Thou hast set a bound that they may not pass over.

A fanciful and presumptuous gentleman having made his exceptions against the proportion of water to dry land on our globe, is well answered by Mr. Keil; that the objections proceed from a deep ignorance of natural philosophy. For if there were but half the sea that now is, there would be but half the vapours; and we should soon find our miserable want of these.

Mr. Ray assures us, that where the bottom of the sea is not rocky, but earth, ouze, or sand, which is incomparably the greatest part of it, it is by the motion of the waters, as far as the reciprocation of the sea extends to the bottom, every where brought to a level; that is to say, it has an equal and uniform descent from the shores to the deeps.

That the motion of the water descends to a good depth, is proved from the plants, that grow deepest in the sea; which all generally grow flat, in manner of a fan, and not with branches on all sides like trees; a thing that is contrived by the Divine Providence, for that the edges of them do in that posture with most ease, cut the water flowing to and fro. Probably in the greater depths of the sea there grow no plants at all; the bottom is probably too remote for the external air to pass in a sufficient quantity thither. Nay, we are told that in those deep seas there are no fish at all; their spawn would be lost there: being lighter than the water, it will not sink thither; and the climate there may be too cold for the quickening of it.

According to Mr. Halley's experiment, water as warm as the air in the summer, will in twelve hours exhale the tenth part of an inch. This quantity will be found abundantly sufficient for all the rains, and all the dews, and all the springs in the world: and will account for the Caspian Sea, and our vast Canadian Lakes, being always at a stand; and for the current, said always to set in at the streights of Gibraltar, though the Mediterranean receive so many rivers. Every ten square inches of the surface of the water, yields

in vapour per diem (we allow it only for the time the sun is up) a cube inch of water. Every mile will yield 6914 tons. A square degree of sixty-nine English miles will yield thirty-three millions of tons. If the Mediterranean Sea be estimated at forty degrees long, and four broad, which is the least, the whole Mediterranean must lose in vapours in a summer's-day at least 5280 millions of tons. And yet sometimes the winds lick up the surface of water faster than it exhales by the heat of the sun. The Mediterranean Sea receives nine considerable rivers. We will suppose each of them to bring down ten times as much water as the river Thames, which they do not; but this will allow for the small rivulets. The Thames, allowing the water to run after the rate of two miles an hour, may yield 20,300,000 tons per diem. Allow as before, and all the nine rivers bring down 1827 millions of tons in a day. This is but little more than a third of what is proved to be evaporated out of the Mediterranean in twelve hours time.

The astonishing flux and reflux of the sea, what benefits it affords to the world! If the ocean once were stagnated, first all the places towards the shore would be turned into a mephitis; and then by degrees it would yet further corrupt, till the whole became as poisonous as the lake of Sodom. The fishes would be first hereby destroyed, and by the poisonous steams, anon the plants and animals would share in the destruction. In the tide of the sea the waters are lifted up in an heap, and then let fall again. So the feared corruption is prevented: and how many conveniences afforded for our navigation! But what? Oh!

what the original of it? Where is the zaphnath paaneah who shall enlighten us?

On our globe all bodies have a tendency towards the centre of it. And such a gravitation there is towards the centre of the sun, and of the moon, and of all the planets. There is cause to suspect that the force of gravity is, in the celestial globes, proportional to the quantity of matter in each of them. The sun, for instance, being more than ten thousand times as big as the earth, its gravitation, and the attracting force of it, is ten thousand times as much as that of the earth, acting on bodies at the same distances.

If our globe were alone, or not affected by the actions of the sun and the moon, the ocean, equally pressed by the force of gravity towards the centre, would continue in a perfect stagnation, always at the same height, without ever ebbing or flowing. But it is demonstrated, that the sun and the moon have a like principle of gravitation towards their centres, and our globe is also within the activity of their attractions. Whence it will follow, that the equality of the pressure of gravity towards the centre will be thereby disturbed. And though the smallness of these forces, in respect of the gravitation towards the centre of the earth, render them imperceptible, yet the ocean being fluid, and yielding to the least force, by its rising shews where there is the least pressure upon it, and where it is most pressed, by sinking. Accordingly we shall find, that where the moon is perpendicularly either above or below the horizon, there the force of gravity is most of all diminished, and consequently that there the ocean must necessarily swell, by the coming in of the water from

those parts where the pressure is greatest, namely, in those where the moon is near the horizon. The sea, which otherwise would be spherical, upon the pressure of the moon must form itself into a spheroidal or oval figure, whose longest diameter is where the moon is vertical, and shortest where she is in the horizon; and the moon shifting her position as she turns round our globe once a day, this oval of water shifts with her, occasioning thereby the two floods and ebbs observable in each five and twenty hours. The spring-tides upon the new and full moons, and the neap tides upon the quarters, are occasioned by the attractive force of the sun in the new and full, conspiring with the attraction of the moon, and producing a tide by their united forces. Whereas in the quarters the sun raises the water where the moon depresses, and on the contrary; so as the tides are made only by the difference of their attraction. The sun and moon being either conjoined or opposite in the equinoctial, produce the greatest spring-tides. The subsequent neap-tides being produced by the tropical moon in the quarters, are always the least tides.

But then from the shoalness of the water in many places, and from the narrowness of the straits, by which the tides are in many places propagated, there arises a mighty diversity, which, without the knowledge of the places, cannot be accounted for.

Dr. Cheyne has taught me to take notice of one thing more. If our earth had any more than one moon attending it, we should receive probably a detriment from it, rather than an advantage. For at the conjunction and opposition with one anoth-

er, and with the sun, we should have tides that would raise the waters to the tops of our mountains, and in their quadratures we should have no tides at all.

O my soul, beholding the moon above, look up to God, who hath so wisely proportioned her, for the designs on which He placed her there.

The sea is the grand fountain of those fresh waters, which supply and enrich the earth, and by convenient channels are carried back to the place from whence they came; how equally are these fresh waters distributed? how few Antigua's in the world? how agreeably are they disposed? and what a prodigious run have many of the rivers? The Danube, in a sober account, as Bohun computes, runs fifteen hundred miles in a straight line from its rise to its fall. The Nile, according to Varenius, allowing for curvatures, runs three thousand miles; and the Niger two thousand four hundred; the Ganges twelve hundred; the Amazonian above thirteen hundred Spanish leagues.

"But is it not high time for us to hear the voice of many waters!

"One celebrating the bounty of our God to us in the water, so expresses it: The contemplation may be carried to the element that is next above it."

Long since have we been taught such notes as these, "O Lord, how manifold are thy works! in wisdom hast thou made them all. The earth is full of thy riches. And so is the great and wide sea, wherein are swimming things innumerable.

"But can we look on the sea, and not see a picture of a troublesome world; see and be instructed."

APPENDIX.

We can scarce leave the water without some remarks on our fluids; and we will be more particularly indebted to Dr. Cheyne for hinting them. How frugal is nature in principles, and yet how fruitful in compositions and in consequences! The primary fluids are but four, water, air, mercury and light. It is but seldom that three of these are much compounded with others. It is water alone, it is lymph, that is mostly the basis of all other mixtures; and it is the parts of solid bodies floating in this fluid that produce all our pleasant and useful varieties of liquors.

How vast the difference between the specific gravities of our fluids! Mercury is about eight thousand times heavier than air. Air must have choaked us, if it had been half so heavy as mercury.

And yet mankind in its present circumstances of the blood vessels, under frequent obstructions, could not well have done without such an heavy fluid as mercury.

All fluids agree in the condition of the direction of their pressure upon the sides of the containing vessel. This pressure is for ever communicated in lines perpendicular to the sides of the containing vessel. This beautiful and uniform property of all fluids necessarily follows from the sphericity of their constituent particles.

Our doctor's conclusion is as I would have it. "Now could any thing but the almighty power of God have rounded those infinite numbers of small particles whereof fluids consist? Or could any thing but his wisdom have assigned them their true dimensions, their exact weights, and required solidities?"

it, Behold, there is a God, whom I ought for ever to love, serve, and glorify. Yea, and if I am tempted to the doing of any wicked thing, I may reflect that it cannot be done without some action wherein the weight of matter operates. But then I may carry on the reflection, How near am I to that glorious God, whose commands I am going to violate! Matter keeps his laws; but, O my soul, wilt thou break them? How shall I do this wickedness, and therein deny the God, who not only is above, but also is most sensibly now exerting his power in the very matter, upon which I make my criminal misapplications!"

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had; and so they become specifically lighter, and the weightier atmosphere buoys them up. The streams of these vapours rest in places where the air is of equal gravity with them, and are carried up and down the atmosphere by the course of that air, till they hit at last against the sides of the mountains, and by this concussion are condensed, and thus become heavier than the air they swam in, and so gleet down the rocky caverns of these mountains, the inner parts whereof being hollow and stony, afford them a basin, until they are accumulated in sufficient quantities, to break out at the first crany: whence they descend into plains, and several of them uniting, form rivulets; and many of them uniting, grow into rivers. This is the story of them; this their pedigree!

Minerals are dug out of mountains; which, if they were sought only in level countries, the delfs would be so flown with waters, that it would be impossible to make addits or soughs to drain them.

The habitations and situations of mankind are made vastly more comfortable for the mountains. There is a vast variety of plants proper to the mountains: and many animals find the mountains their most proper places to breed and feed in. The highest hills a refuge to the wild goats. A point Mr. Ray has well spoken to.

They report that Hippocrates did usually repair to the mountains for the plants, by which he wrought the chief of his cures.

Mountains also are the most convenient boundaries to territories, and afford a defence to them. One calls them the bulwarks of nature, cast up at the charges of the Almighty; the scorns and curbs of the most victorious armies. The barba-

rians in Curtius were confidently sensible of this! Yea, we may appeal to the senses of all men, whether the grateful variety of hills and dales be not more pleasing that the largest continued plains.

It is also a salutary conformation of the earth; some constitutions are best suited above, and others below. Truly these massy and lofty piles can by no means be spared.

Galen, thou shalt chastise the pseudo Christians, who reproach the works of God. Say! say now, O man, say, under the sweet constraints of demonstration, great God, the earth is full of thy goodness! And Dr. Grew shall carry on the more general observation for us. "How little is the mischief which the air, fire, or water sometimes doth, compared with the innumerable uses to which they daily serve? Besides the seas and rivers, how many wholesome springs are there for one that is poisonous? Are the northern countries subject to cold? they have a greater plenty of furs to keep the people warm. Would those under or near the line be subject to heat? they have a constant easterly breeze, which blows strongest in the heat of the day, to refresh them: and with this refreshment without, they have a variety of excellent fruits to comfort and cool them within. How admirably are the clouds fed with vapours, and carried about with the winds, for the gradual, equal, and seasonable watering of most countries? and in those which have less rain, how abundantly is the want of that supplied with noble rivers?"

Even the subterraneous caverns have their uses. And so have the ignivomous mountains: those terrible things are spiracles, to vent the vapours,

which else might make a dismal havoc. Dr Woodward observes, that those places which are very subject to earthquakes usually have these volcanos, yet without these fiery vents their earthquakes would bring more tremendous desolations upon them.

Those two flammivomous mountains, Vesuvius and Ætna, have sometimes terrified the whole world with their tremendous eruptions. Vesuvius transmitted its frightful cinders as far as Constantinople, which obliged the emperor to leave the city; an historian tells us there was kept an anniversary commemoration of it. Kircher has given us a chronicle of what furious things have been done by Ætna; the melted matter which one time it poured forth, spreading in breadth six miles, ran down as far as Catanea, and forced a passage into the sea.

Asia abounds in these volcanos. Africa is known to have eight at least. In America it is affirmed that there are no less than fifteen, among that vast chain of mountains called the Andes. One says, "Nature seems here to keep house under ground, and the hollows of the mountains to be the funnels or chimneys, by which the fuliginous matter of those everlasting fires ascends."

The north too, that seems doomed to eternal cold, has its famous Hecla. And Bartholomew Zenet found one in Greenland, yet nearer to the pole; the effects whereof are very surprising.

A reasonable and religious mind cannot behold these formidable mountains, without some reflections of this importance: great God, who knows the power of thine anger? or what can stand before the powerful indignation of that God, who

can kindle a fire in his anger that shall burn to the lowest hell, and set on fire the foundations of the mountains!

The volcanos would lead us to consider the earthquakes, wherein the earth often suffers violent, and sometimes very destructive concussions.

The history of earthquakes would be a large, as well as a sad volume. Whether a colluctation of minerals in the bowels of the earth is the cause of those direful convulsions, may be considered: as we know a composition of gold which aqua regia has dissolved; sal armoniack, and salt of tartar, set on fire, will with an horrible crack break through all that is in the way. But mankind ought herein to tremble before the justice of God. Particular cities and countries, what fearful desolations have been by earthquakes brought upon them!

The old sinking of Helice and Buris, absorbed by earthquskes into the sea, mentioned by Ovid, or the twelve cities that were so swallowed up in the days of Tiberius, are small things to what earthquakes are to do on our globe; yea, have already done. I know not what we shall think of the huge Atlantis, mentioned by Plato, now at the bottom of the Atlantic ocean: but I know Varenius thinks it probable, that the northern part of America was joined to Ireland, till earthquakes made the vast and amazing separation. Others have thought so of England and France; of Spain and Africa; of Italy and Sicily.

Ah, Sicily! art thou come to be spoken of? no longer ago than the other day what a rueful spectacle was there exhibited in the island of Sicily by an earthquake, in which there perished the greater part of two hundred thousand souls!

O inhabitants of the earth, how much ought you to fear the things that will bring you into ill terms with the glorious God! fear, lest the pit and the snare be upon you! against all other strokes, there may some defence or other be thought on: there is none against an earthquake! It says, though they hide in the top of Carmel, I will find them there.

But surely the earthquakes I have met with will effectually instruct me to avoid the folly of setting my heart inordinately on any earthly possessions or enjoyments. Methinks I hear heaven saying, surely he will receive this instruction!

A modern philosopher speaks at this rate, "We do not know when and where we stand upon good ground: it would amaze the stoutest heart, and make him ready to die with fear, if he could see into the subterraneous world, and view the dark recesses of nature under ground; and behold, that even the strongest of our piles of building, whose foundation we think is laid firm and fast, yet are set upon an arch or bridge, made by the bending parts of the earth one upon another; over a prodigious vault, at the bottom of which there lies an unfathomable sea, but its upper hollows are filled with stagnating air, and with expirations of sulphureous and bituminous matter. Upon such a dreadful abyss we walk, ride and sleep; and are sustained only by an arched roof, which also is not in all places of an equal thickness."

Give me leave to say, I take earthquakes to be very moving preachers to worldly-minded men: their address may be very agreeably put into the terms of the prophet; O earth, earth, earth, hear *the word of the Lord!*

"Chrysostom did well, among his other epithets, to call the earth our table; but it shall teach me as well as feed me; may I be a deipnosophist upon it.

"Indeed, what is the earth but a theatre, as has been long since observed? But I must not forget that this earth is very shortly to be my sleeping place; it has a grave waiting for me: I will not fear to go down, for thou hast promised, O my Saviour, to bring me up again."

APPENDIX.

HAVING arrived thus far, I will here make a pause, and acknowledge the shine of heaven on our parts of the earth, in the improvements of our modern philosophy.

To render us the more sensible of this, we will propose a few points of the Mahometan philosophy, or secrets revealed to Mahomet, which none of his followers, who cover so much of the earth at this day, may dare to question.

The winds; it is an angel moving his wings that raises them.

The flux and reflux of the sea, is caused by an angel's putting his feet on the middle of the ocean, which compressing the waves, the waters run to the shores; but being removed, they retire into their proper station.

Falling stars are the firebrands with which the good angels drive away the bad, when they are too saucily inquisitive, and approach too near the verge of the heavens, to eves-drop the secrets there.

Thunder is nothing else but the cracking an an angel's whip, while he flashes the dull clouds into

such and such places, when they want rains to fertilize the earth.

Eclipses are made thus: the sun and moon are shut in a pipe, which is turned up and down; from each pipe is a window, by which they enlighten the world; but when god is angry at the inhabitants of it for their transgressions, he bids an angel clap to the window, and so turn the light towards heaven from the earth: for this occasion forms of prayer are left, that the almighty would avert his judgments, and restore light to the world.

The thick skulled prophet sets another angel at work for earthquakes; he is to hold so many ropes tied to every quarter of the globe, and when he is commanded, he is to pull; so he shakes that part of the globe: and if a city, or mountain, or tower, is to be overturned, then he tugs harder at the pulley, till the rivers dance, and the valleys are filled with rubbish, and the waters are swallowed up in the precipices.

May our devotion exceed the Mahometan as much as our philosophy!

ESSAY XXIV. *Of* MAGNETISM.

SUCH an unaccountable thing there is as the magnetism of the earth. A principle very different from that of gravity. The operations of this amazing principle, are chiefly discovered in the communion that iron has with the loadstone; a rough, coarse, unsightly stone, but of more value than all the diamonds and jewels in the universe.

It is observed by Sturmius, that the attractive quality of the magnet was known to the ancients,

even beyond all history. Indeed, besides what Pliny says of it, Aristotle speaks of Thales, as having said, the stone has a soul, because it moves iron.

It was Roger Bacon who first of all discovered the verticity of the magnet, or its property of pointing towards the pole, about four hundred years ago.

The communication of its virtue to iron was first of all discovered by the Italians. One Goia first lit upon the use of the mariner's compass, about A. D. 1300. After this, the various declination of the needle under different meridians, was discovered by Cabot and Norman. And then the variation of the declination, so as to be not always the same in one and the same place, by Hevelius, Auzot, Volckamer, and others.

The inquisitive Mr. Derham says, the variation of the variation, was first found out by our Gellibrand, A. D. 1634. And he himself has added a further discovery; That as the common needle is continually varying towards the east and west, so the dipping needle varies up and down, towards the zenith, or forwards, with a magnetic tendency, describing a circle round the pole of the world, or some other point; a circle, whereof the radius is about 13 degrees.

In every magnet there are two poles, the one pointing to the north, and the other to the south.

The poles, in divers parts of the globe, are diversely inclined towards the centre of the earth. These poles, though contrary to one another, do mutually help towards the magnet's attraction, and suspension of iron.

If a stone be cut or broke into ever so many

pieces, there are these two poles in each of the pieces.

If two magnets are spherical, one will conform itself to the other, so as either of them would do to the earth; and after they have so turned themselves, they will endeavour to approach each other: but placed in a contrary position, they avoid each other.

If a magnet be cut through the axis, the segments of the stone, which before were joined, will now avoid and fly each other.

If the magnet be cut by a section perpendicular to its axis, the two points, which before were conjoined, will become contrary poles; one in one, the other in the other segment.

Iron receives virtue from the magnet, by application to it, or barely from an approach near it, though it do not touch it; and the iron receives this virtue variously, according to the parts of the stone it is made to approach to.

The magnet loses none of its own virtue by communicating any to the iron. This virtue it also communicates very speedily; though the longer the iron joins the stone, the longer its communicated virtue will hold. And the better the magnet, the sooner and stronger the communicated virtue.

Steel receives virtue from the magnet better than iron. A needle touched by a magnet, will turn its ends the same way towards the poles of the world as the magnet will do it. But neither of them conform their poles exactly to those of the world; they have usually some variation, and this variation too in the same place is not always the same.

A magnet will take up much more iron when armed or capped than it can alone. And if the iron ring be suspended by the stone, yet the magnetical particles do not hinder the ring from turning round any way, to the right or left.

The best magnet, at the least distance from a lesser or a weaker, cannot draw to it a piece of iron adhering actually to a much weaker or lesser stone; but if it come to touch it, it can draw it from the other. But a weaker magnet, or even a little piece of iron can draw away or separate a piece of iron, contiguous to a better and greater magnet. In our northern parts of the world, the south pole of a loadstone will raise more iron than the north pole.

A plate of iron only, but no other body interposed, can impede the operation of the loadstone, either as to its attractive or directive quality. The power and virtue of the loadstone may be impaired by lying long in a wrong posture, as also by rust, and wet, and the like. A magnet heated red hot, will be speedily deprived of its attractive quality; then cooled, either with the south pole to the north, in an horizontal position, or with the south pole to the earth in a perpendicular, it will change its polarity; the southern pole becoming the northern, and *vice versa*.

By applying the poles of a very small fragment of a magnet to the opposite vigorous ones of a larger, the poles of the fragment have been speedily changed.

Well tempered and hardened iron tools, heated by attrition, will attract filings of iron and steel.

The iron bars of windows, which have stood long in an erect position, do grow permanently *magnetical*; the lower end of such bars being the

northern poles, and the upper the southern. Mr. Boyle found English ochre, heated red hot, and cooled in a proper posture, plainly to gain a magnetic power. The illustrious Mr. Boyle, and the inquisitive Mr. Derham, have carried on their experiments, till we are overwhelmed with the wonders, as well as with the numbers of them. That of Mr. Derham, and Grimaldi, that a piece of well touch iron wire, upon being bent round in a ring, or coiled round upon a stick, loses its verticity, is very admirable. The strength of some loadstones is very surprising.

Dr. Lister saw a collection of loadstones, one of them weighed naked not above a dram, yet it would raise a dram and half of iron; but being shod, it would raise one hundred and forty and four drams. A smooth loadstone, weighing 65 grains, drew up 14 ounces; that is, 144 times its own weight. A loadstone that was no larger than a hazel nut, brought up a large bunch of keys.

The effluvia of a loadstone seem to work in a circle. What flows from the north pole, comes round, and enters the south pole; and what flows from the south pole, enters the north pole.

Though a minute loadstone may have a prodigious force, yet it is very strange to see what a short sphere of activity it has; it affects not the iron sensibly above an inch or two, and the biggest little more than a foot or two. The magnetic effluvia make haste to return to the stone that emitted them, and seem afraid of leaving it, as a child the mother before it can go alone.

On that astonishing subject, the variation of the *compass*, what if we should hear the acute Mr.

Halley's proposals? He proposes, that our whole globe should be looked upon as a great magnet, having four magnetical poles, or points of attraction, two near each pole of the equator. In those parts of the world which lie near adjacent to any one of these magnetical poles, the needle is governed by it; the nearer pole being always predominant over the remoter. The pole which at present is nearest to Britain, lies in or near the meridian of the Lands-end of England, and not above seven degrees from the arctic pole. By this pole the variations in all Europe, and in Tartary, and in the north sea, are principally governed, though with some regard to the other northern pole, which is in a meridian passing about the middle of California, and about fifteen degrees from the north pole of the world. To this the needle pays its chief respect in all North America, and in the two oceans on either side, even from the Azores westward, to Japan, and further. The two southern poles are distant rather further from the south pole of the world; the one is about sixteen degrees from it, and is under a meridian about twenty degrees to the westward of the Magellanic streights; this commands the needle in all South America, in the Pacific Sea, and in the greatest part of the Ethiopic ocean. The fourth and last pole seems to have the greatest power and the largest dominions of all, as it is the most remote from the pole of the world; for it is near twenty degrees from it, in the meridian which passes through Hollandia Nova, and the island Celebes. This pole has the mastery in in the south part of Africa, in Arabia, and the Red Sea, in Persia, in India, and its islands, and all over the Indian Seas,

from the Cape of Good Hope eastward, to the middle of the great South Sea, which divides Asia from America. Behold, the disposition of the magnetical virtue, as it is throughout the whole globe of the earth at this day! But now to solve the phenomena! we may reckon the external parts of our globe as a shell, the internal as a nucleus, or an inner globe included within ours; and between these a fluid medium, which having the same common centre and axis of diurnal rotation, may turn about with our earth every four and twenty hours: only this outer sphere having its turbinating motion some small matter either swifter or slower than the internal ball, and a very small difference becoming in length of time sensible by many repetitions; the internal parts will by degrees recede from the external, and not keeping pace with one another, will appear gradually to move, either eastward or westward, by the difference of their motions. Now if the exterior shell of our globe should be a magnet, having its poles at a distance from the poles of diurnal rotation; and if the internal nucleus be likewise a magnet, having its poles in two other places, distant also from the axis, and these latter, by a slow and gradual motion, change their place in respect of the external, we may then give a reasonable account of the four magnetical poles, and of the changes of the needle's variations. Who can tell but the final cause of the admixture of the magnetical matter in the mass of the terrestrial parts of our globe, should be to maintain the concave arch of this our shell? Yea, we may suppose the arch lined with a magnetical matter, or to be rather one great concave magnet, whose two poles are

fixed in the surface of our globe? Sir Isaac Newton has demonstrated the moon to be more solid than our earth, as nine to five; why may we not then suppose four ninths of our globe to be cavity? Mr. Halley allows there may be inhabitants of the lower story, and many ways of producing light for them. The medium itself may be always luminous; or the concave arch may shine with such a substance as does invest the surface of the sun; or they may have peculiar luminaries, whereof we can have no idea.

The diameter of the earth being about eight thousand English miles, how easy it is to allow five hundred miles for the thickness of the shell! and another five hundred miles for a medium capable of a vast atmosphere, for the globe contained within it!—But it is time to stop, we are got beyond human penetration; we have dug as far as it is fit any conjecture should carry us.

It is a little surprising that the orb of the activity of magnets, as Mr. Derham observes, is larger or lesser at different times. There is a noble and mighty loadstone reserved in the repository at Gresham college, which will keep a key, or other piece of iron, suspended to another, sometimes at the distance of eight or ten feet from it, but at other times not above four. A dgression, if worthy to be called so!

But is it possible for me to go any further without making an observation, which indeed would now and then break in upon us as we go along? Once for all, gentlemen philosophers, the magnet has quite puzzled you. It shall then be no indecent anticipation of what should have been observed at the conclusion of this collection, here to de-

mand it of you, that you glorify the infinite Creator of this, and of all things, as incomprehensible. You must acknowledge that human reason is too feeble, too narrow a thing to comprehend the infinite God. The words of our excellent Boyle deserve to be recited on this occasion: "Such is the natural imbecility of the human intellect, that the most piercing wits and excellent mathematicians are forced to confess, that not only their own reason, but that of mankind, may be puzzled and nonplused about quantity, which is an object of contemplation natural, nay, mathematical. Wherefore why should we think it unfit to be believed, and to be acknowledged, that in the attributes of God, and in his dispensations towards the children of men, there should be some things which our finite understanding cannot clearly comprehend? And we who cannot clearly comprehend how in ourselves two such distant natures, as that of a gross body and an immaterial spirit should be so united as to make up one man, why should we grudge to have our reason pupil to an omniscient Instructor, who can teach us such things, as neither our own mere reason, nor any others, could ever have discovered to us?"

I will now single out a few plain mathematical instances, wherein, sirs, you will find your finest reason so transcended, and so confounded, that it is to be hoped a profound humility in the grand affairs of our holy religion will from this time for ever adorn you.

Mr. Robert Jenkin discoursing on the reasonableness of the Christian religion, gives two instances how much we may lose ourselves in the *speculation of material things.*

First, nothing seems more evident, than that all matter is divisible; yea, the least particle of matter must be so, because it has the nature and essence of matter: it can never be so divided that it shall cease to be matter. But then, on the other side, it is plain, matter cannot be infinitely divisible; because whatever is divisible, is divisible into parts; and parts can be infinite, because no number can be so. A numberless number is a contradiction; all parts are capable of being numbered; they are more or fewer, odd or even. It is not enough to say, that matter is only capable of such a division, but never can be actually divided into infinite parts; for the parts into which it is divisible must be actually existent, though they be not actually divided. And last of all to say, these parts of matter are indefinite, but not infinite, is only to confess we know not what to say.

Second, we all agree that all the parts into which the whole is divided, being taken together are equal to the whole. But it seems any single part is equal to the whole. It is granted, that in any circle a line may be drawn from every point of the circumference to the centre. Suppose the circle to be the equator, and a million lesser circles are drawn within the equator, about the same centre, and then a right line drawn from every point of the equator to the centre of the globe; every such right line drawn from the equator to the centre, must of necessity cut through the million lesser circles, about the same centre: consequently there must be the same number of points in a circle a million of times less than the equator, as there is in the equator itself. The lesser circles may be multiplied into as many as there are

points in the diameters; and so the least circle imaginable may have as many points as the greatest; that is, be as large as the greatest, as large as one that is a million of times as large as itself.

Yet more; what will you say to this? Let a radius be moved as a radius upon a circle; it is a case of Dr. Grew's proposing: whether we suppose it wholly moved, or but in part, the supposition will bring us to an absurdity; if it be in a part movent, and in a part quiescent, it will be a curve line, and no radius; if it be wholly movent, then it moves either about or upon the centre; if it moves about it, it then comes short of it, and so again is no radius; it cannot move upon it, because all motion having parts, there can be no motion upon a point.

More yet; we cannot conceive how the perimeter of a circle, or other curve figure, can consist without being infinitely angular; for the parts of a line are lines: but we cannot conceive how those lines can have, as here they have, a different direction, and therefore an inclination, without making an angle. And yet if you suppose a circle to be angular, you destroy the definition of a circle, and the theorems depending on it.

Once more; I will offer a case of my own. The line on which I am now writing is a space between two points; it will be doubtless allowed me, that my pen in passing over this line, from the one point to the other, must pass over the half of the line before it passes over the whole; and so the half of the remaining half, and so the half of the quarter that remains: so still the half of the remaining space, the half before the whole; and yet when it comes to execution, you find it is not

so. If the position you allowed me had been true, my pen would not have reached to the end of the line before the end of my life; or in a term wherein it might have written ten books as large as old Zoroaster's, or more manuscripts than ever were in the Alexandrian library.

It is then evident, that all mankind are to this day in the dark as to the ultimate parts of quantity, and of motion.

Go on my learned Grew, and maintain (who more fit than one of thy recondite learning?) that there is hardly any one thing in the world, the essence whereof we can perfectly comprehend. But then to the natural imbecility of reason, and the moral depravations of it, by our fall from God, and the ascendant which a corrupt and vicious will has obtained over it, how much ought this consideration warn us against the conduct of an unhumbled understanding in things relating to the kingdom of God? I am not out of my way, I have had a magnet all this while steering of this digression: I am now returning to that.

God forbid that I should be so much a stone, as to think a stone a deity. To fall down before a stone, and say, thou art a God, would be an idolatry, that, none but a soul more senseless than a stone could be guilty of. But then it would be a very agreeable and acceptable homage to the glorious God, for me to see much of Him in such a wonderful stone as the magnet. They have done well to call it the loadstone, that is to say, the lead-stone: may it lead me unto thee, O my God and my Saviour! magnetism is in this like to gravity, that it leads us to God, and brings us very near to him. When we see magnetism in its

operation, we must say, this is the work of God! and of the stone, which has proved of such vast use in the affairs of the waters that cover the sea, and will ere long do its part in bringing it about that the glory of the Lord shall cover the earth, we must say, great God, this is a wonderful gift of thine to the world!

I do not propose to exemplify the occasional reflections which a devout mind may make upon all the creatures of God, their properties, and actions, and relations; the libri elephantini would not be large enough to contain the thousandth part of them. If it were lawful for me here to pause with a particular exercise upon the loadstone, my first thoughts would be those of the holy Scudder, whose words have had a great impression on me ever since my first reading them in my childhood: "An upright man is like a needle touched with the loadstone; though he may through boisterous temptations and strong allurements oftentimes look towards the pleasure, gain and glory of this present world, yet because he is truly touched with the sanctifying Spirit of God, he still inclineth God-ward, and hath no quiet till he stand steady towards heaven." However, to animate the devotion of my Christian philosopher, I will here make a report to him. The ingenious Ward wrote a pious book, as long ago as the year 1639, entitled, Magnetis Reductorium Theologicum. The design of his essay is, to lead us from the consideration of the loadstone, to the consideration of our Saviour, and of his incomparable glories; whereof the magnet is a remarkable representation.

Christian, in the loadstone drawing and lifting

up the iron, behold thy Saviour drawing us to himself, and raising us above the secular cares and snares that ruin us. In its ready communication of its virtues, behold a shadow of thy Saviour communicating his holy Spirit to his chosen people; and his ministers more particularly made partakers of his attractive powers. When silver and gold are neglected by the loadstone, but coarse iron preferred, behold thy Saviour passing over the angelic world, and choosing to take our nature upon him. The iron is also undistinguished, whether it be lodged in a fine covering, or whether it be lying in the most wretched circumstances; which invites us to think how little respect of persons there is with our Saviour. However, the iron should be cleansed, it should not be rusty; nor will our Saviour embrace those who are not so far cleansed, that they are at least willing to be made clean, and have his files pass upon them. The iron is at first merely passive, then it moves more feebly towards the stone; anon upon contact it will fly to it, and express a marvellous affection and adherence. Is not here a picture of the dispositions in our souls towards our Saviour? It is the pleasure of our Saviour to work by instruments, as the loadstone will do most when the mediation of a steel cap is used about it. After all, whatever is done, the whole praise is due to the loadstone alone. But there would be no end, and indeed there should be none, of these meditations. Mr. Ward in his dedication of his book to the king, has one very true compliment. I take it upon me to assure your majesty, that if you alone possessed it, you might easily make yourself the monarch of the

whole world. But what a great king is He, who is the owner, yea, and the maker of all the magnets in the world! I am a great king, saith the Lord of hosts, and my name is to be feared among the nations! may the loadstone help to carry it to them.

ESSAY XXV. *Of* MINERALS.

OUR earth is richly furnished with a tribe of minerals, called so because dug out of mines; and because dug, therefore also called fossils. Many things to be written of these, ought to have a nimok in the margin.

The adventitious fossils, which are but the exuviæ of animals, have been erroneously thought a sort of peculiar stones. These must be excluded. But then the natives of the earth are to be found in a vast variety. The inquisitive Dr. Woodward has prepared us a noble table of them. There are near twenty several sorts of earth. Of these, besides the potter's earth, and the fuller's earth, how exceedingly useful is the chalk to us, there are above a dozen several sorts of stones, that are found in larger masses. What vessels, what buildings, what ornaments, do these afford us; especially the slate, the marble, the free stone, and the lime-stone? How helpful the warming-stone? How needful the grind-stone and mill-stone? To the service of our Maker we have many calls from the stones themselves, for if men should be silent at proclaiming the glory of God, the very stones would speak.

The whetstone gives me a particular admonition, which I have somewhere met with. Many men give instructions to others, which they refuse

to obey themselves. The worst motto for a divine that can be! Lord, save me from it!

How astonishing the figures, which Dr. Robinson and Mr. Ray report, as naturally delineated upon several kinds of stones; almost every thing in nature described in them, so as could not be out done by any sculptor or painter! the colaptice, such as no human skill could arise to.

Yea, in stones there have been sometimes found so much of the human shape, that every thing in it has been really astonishing. Zeiler and Kircher mention some famous rocks, which so resemble monks, that all people call them so. Olaus Wormius was possessor of a large stone, which had exactly the head, face, neck and shoulders of a man. Monconnys and others relate the several parts of a man, which many stones have exactly exhibited. Oh! how happy we, if men and stones had less resemblance!

There are many sorts of stones found in lesser masses. Of these there are many which do not exceed the hardness of marble. Seven or eight of these are of an indeterminate figure. Twice as many have a determinate figure. Among these the wonders of the osteo-colla, to join and heal our broken bones. But then there are others which do exceed marble in hardness. To this article belong those that are usually called gems or precious stones. Pebbles and flints are of the agate kind. Some of these are opaque. Three of the opaque have a body of one colour. Here the wonders of the nephritic stone. Three of the opaque have different colours mixed in the same body. Here the wonders of the blood-stone, Some are pellucid. Two with colours changeable.

according to their different position in the light. Nine or ten with colours permanent. Some are diaphanous. Two yellow, or partaking of it. Three red. Three blue. Two green. Four without any colours.

"But an excellent writer observes, God is the former of stones, and carries on his observation, that the God who makes precious as well as common stones, has made men with as much difference, and not altogether without such a proportion."

"Good God, thy heavenly graces in the soul are brighter jewels than any that are dug out of the earth. A poor man may be adorned with these; those who are so, they shall be mine, saith the Lord, in the day when I make up my jewels." "How often have I seen a jewel in the snout of a swine! And how many counterfeits in the world!"

There are seven sorts of salts to be met with. But the salt of our table, of how much consequence this to us! the uses of it are too many to be by any reckoned: very many are well known to all. To which add the experience which Bickerus affirms the army of the emperor Charles V. had, that they must have perished on the African shore, if they had not found a grain of salt in their mouths; an antidote not only against thirst, but hunger too.

He deserves to be herded with the brutes, who is insensible, that the benefits of salt call for very great acknowledgments. My God, save me from what would render me unsavoury salt!

There are three liquid bitumens, six or seven solid. There are about a dozen metallic minerals. Mercury is one of these, but how astonishing an one! The particles whereof how small, how smooth,

how solid! The corpuscles of it have diameters much less than those of air; yea, than those of water; and not much greater than those of light itself!

At last we come to metals; iron, with its attendants; tin, lead, copper, silver and gold. "I shall not consider the reasons which moved Cardan to assert that metals have a soul; but I am sure that I myself have a soul, and one that is reasonable; if so, what can be more agreeable to me, than a consideration which I find hinted by a curious writer of natural theology: we should admire the munificence of one who would bestow a considerable quantity of enriching metals upon us. But then how much cause have we to adore the munificence of our bountiful God, who has enriched us with metals in so vast a quantity, and with so much profusion from his hidden treasures!"

How amazingly serviceable is iron to us! in mechanical arts, in agriculture, in navigation, and in architecture; in all, I say, all our business! What a sordid life do those barbarians lead, who are kept ignorant of it! unthankful for this, O man, you deserve that heaven should become as iron over you.

It is from God that the metals of most necessary uses are the most plentiful; others that may be better spared, there is a rarity of them. That one single metal, iron, as Dr. Grew observes, sets on foot above an hundred sorts of manual operations.

Though the love of money be the root of all evil, yet the ingenious Dr. Cockburn has discoursed very justly on the vast importance whereof the use of money is to mankind. And indeed where the use of money has not been introduced,

men are brutish and savage, and nothing that is good has been cultivated.

There is a surprising providence of God in keeping up the value of gold and silver, notwithstanding the vast quantities dug out of the earth in all ages, ever since the trade began of mining; and so continuing them fit materials for money.

Among the marvellous qualities of gold, its ductility deserves particular notice. The wire-drawers, to every 48 ounces of silver, allow one of gold. Now two yards of the superfine wire weigh a grain. In the length of 98 yards there are 49 grains of weight. A single grain of gold covers the said 98 yards. The 10000th part of a grain is above one third of an inch long, which yet may be actually divided into ten; and so the 100000th part of a grain of gold may be visible without a microscope.

It is a marvellous thing that gold, after it has been divided by corrosive liquors into invisible parts, yet may presently be so precipitated, as to appear in its own golden form again.

But, as Dr. Grew observes, the same immutability which belongs to the composition of gold, much more belongs to the principles of gold, and of all other bodies, when their composition is destroyed. Dampier, an ingenious traveller all round the globe, has an observation; I know no place where gold is found, but what is very unhealthy.

"Possessor of gold! beware lest the observation be verified in the unhealthy influences of thy gold upon thy mind; and lest thy love of it betray thee into many foolish and hurtful lusts, which will drown thee in destruction and perdition."

"The *auri sacra fames* is the worst of alldistempers."

My God, I bless thee; I know something that is better than fine gold, something that cannot be gotten for gold, neither shall silver be weighed for the price thereof.

If gold could speak, it would rebuke the idolatry wherewith mankind adore it, in much such terms as I find a devout writer assigning to it. I am not God, but a creature of God, dug from the earth, made for the service of man, that he may serve his God.

"Finally, the pagans not only worshipped the host of heaven, (justly called Zabians) but whatsoever they found comfortable to nature, they also deified. The river Nile too must at length become a deity; yea, gods grew in the Egyptian gardens. "And according to Pliny, a man that helps a man becomes a god." "God save us from the crime stigmatised by our apostle, to adore the creatures more than the Creator! By no means let us, as Philo speaks, more admire the world, than the Maker of the world." "We will glorify the God who has bestowed things upon us; for the silver is mine, and the gold is mine, saith the Lord of Hosts."

ESSAY XXVI. *Of* VEGETABLES.

THE contrivance of our most glorious Creator, in the vegetables growing upon this globe, cannot be wisely observed without admiration and astonishment. We will single out some remarkables, and glorify our God.

First, in what manner is vegetation performed? and how is the growth of plants and the increase

of their parts carried on? The excellent and ingenious Dr. John Woodward has, in the way of nice experiment, brought this thing under a close examination. It is evident that water is necessary to vegetation; there is a water which ascends the vessels of the plants, much after the way of filtration; and the plants take up a larger or lesser quantity of this fluid, according to their dimensions. The much greater part of that fluid mass which is conveyed to the plants, does not abide there, but exhale through them up into the atmosphere. Hence countries that abound with large plants are subject to great damps, rains, and inconvenient humidities. But there is also a terrestrial matter which is mixed with this water, and ascends up into the plants with the water. Something of this matter will attend water in all its motions, and stick by it after all its percolations. Indeed the quantity of this terrestrial matter, which the vapours carry up into the atmosphere, is very small, but it is the truest and the best prepared vegetable matter; for which cause it is that rain water is of such a singular fertility. It is true there is in water a mineral matter also, which is usually too scabrous, ponderous, and inflexible, to enter the pores of the roots. Be the earth ever so rich, it is observed, little good will come of it, unless the parts be loosened a little, and separated. And this probably is all the use of nitre and other salts to plants, to loosen the earth, and separate the parts of it. It is this terrestrial matter which fills the plants; they are more or less nourished and augmented in proportion, as their water conveys a greater or lesser quantity of proper terrestrial matter to them. Nevertheless

it is also probable that in this there is a variety; and all plants are not formed and filled from the same sort of corpuscles. Every vegetable seems to require a peculiar and specific matter for its formation and nourishment.

If the soil wherein a seed is planted, has not all or most of the ingredients necessary for the vegetable to subsist upon, it will suffer accordingly. Thus wheat sown upon a tract of land well furnished for the supply of that grain, will succeed very well, perhaps for divers years, or as the husbandman expresses it, as long as the ground is in heart; but anon it will produce no more of that corn; it will of some other, perhaps of barley: and when it will subsist this no more, still oats will thrive there; and perhaps pease after these. When the ground has lain fallow some time, the rain will pour down a fresh stock upon it; and the care of the tiller in manuring it, lays upon it such things as are most impregnated with a supply for vegetation. It is observed that spring water and rain water contain nearly an equal charge of the vegetable matter, but river water much more than either of them; and hence the inundations of rivers leave upon their banks the fairest crops in the world. It is now plain that water is not the matter that composes vegetables, but the agent that conveys that matter to them, and introduces it into the several parts of them. Wherefore the plentiful provision of this fluid supplied to all parts of the earth, is by Dr. Woodward justly celebrated with a pious acknowledgment of that natural providence that superintends the globe which we inhabit. The parts of water being exactly spherical, and subtile beyond all expression, the surfaces perfectly smooth, and the intervals

being therefore the largest, and so the most fitting to receive a foreign matter into them, it is the most proper instrument imaginable for the service now assigned to it. And yet water would not perform this office and service to the plants, if it were not assisted with a due quantity of heat; heat must concur, or vegetation will not succeed. Hence as the heat of several seasons affords a different face of things, the same does the heat of several climates. The hotter countries usually yield the larger trees, and in a greater variety. And in warmer countries, if there be a remission of the usual heat, the production will in proportion be diminished.

That I may contribute my two mites to illustrate the way vegetation is carried on, I will here communicate two experiments lately made in my neighbourhood:

My neighbour planted a row of hills in his field with Indian corn, but such a grain as was coloured red and blue; the rest of the field he planted with corn of the usual colour, which is yellow. To the most windward side this row infected four of the next neighbouring rows, and part of the fifth, and some of the sixth, to render them coloured like what grew on itself. But on the leeward side no less than seven or eight rows were so coloured, and some smaller impressions were made on those that were yet further distant.

The same neighbour having his garden often robbed of the squashes growing in it, planted some gourds among them, which are to appearance very like them, and which he distinguished by certain adjacent marks, that he might not be himself imposed upon; by this means the thieves

it is true found a very bitter sauce, but then all the squashes were so infected and embittered, that he was not himself able to eat what the thieves had left of them.

That most accurate and experienced botanist Mr. Ray, has given us the plants that are more common, with certain characteristic notes, wherein he establishes twenty five genders of them. These plants are to be rather styled herbs.

But then of the trees and shrubs, he distinguishes five classes that have their flower disjoined and remote from the fruit, and as many that have their fruit and flower contiguous.

How unaccountably is the figure of plants preserved? And how unaccountably their growth determined? Our excellent Ray flies to an intelligent plastic nature, which must understand and regulate the whole economy.

Every particular part of the plant has its astonishing uses. The roots give it a stability, and collect the nourishment which lies in the earth ready for it. The fibres contain and convey the sap which carries up that nourishment. The plant has also larger vessels, which entertain its proper and specific juice, and others to carry the air for its necessary respiration. The outer and inner bark defend it from annoyances, and contribute to its augmentation. The leaves embrace and preserve the flower and fruit as they come to their explication. But the principal use of them, as Malpighi, Perault, and Mariotte, have observed is, to concoct and prepare the sap for the nourishment of the fruit, and of the whole plant; not only that which ascends from the root, but also what they take in from without, from the dew

and from the rain. For there is a regress of the sap in plants from above, downwards; and this descendent juice is that which principally nourishes both fruit and plant, as has been clearly proved by the experiments of signior Malpighi and Mr. Brotherton.

How agreeable the shade of plants, let every man say that sits under his own vine, and under his own fig tree! how charming the proportion and beauty of the leaves, the flowers, the fruits, he who confesses not, must be, as Dr. More says, one sunk into a forlorn pitch of degeneracy, and stupid as a beast!

Our Saviour says of the lilies (which some suppose to be tulips) that Solomon in all his glory was not arrayed like one of these. And it is observed by Spigelius, that the art of the most skilful painter cannot so mingle and temper his colours, as exactly to imitate or counterfeit the native ones of the flowers of vegetables.

Mr. Ray thinks it worthy a very particular observation, that wheat, which is the best sort of grain, and affords the most wholesome bread, is in a singular manner patient of both extremes, both heat and cold, and will grow to maturity as well in Scotland, and in Denmark, as in Egypt, Guinea and Madagascar. It scarce refuses any climate. And the exceeding fertility of it is by a pagan Pliny acknowledged as an instance of the Divine bounty to man, because it affords him his chief nourishment; one bushel in a fit soil, he says, yielding one hundred and fifty. A friend of mine had thirty six ears of rye growing from one grain, and on one stalk. But of our Indian corn, one grain of corn will produce above a thou-

sand. And of Guinea corn, one grain has been known to produce ten thousand.

The anatomy of plants, as it has been exhibited by the incomparable curiosity of Dr. Grew, into what a vast field of wonders does it lead us! the most inimitable structure of the parts! the particular canals, and most adapted ones, for the conveyance of the lymphatic and essential juices! the air vessels in all their curious coilings! the coverings which befriend them, a work unspeakably more curious in reality than in appearance! The strange texture of the leaves, the angular or circular, but always orderly position of their fibres; the various foldings, with a duplicature, a multiplicature, the fore-rowl, the back-rowl, the tre-rowl; the noble guard of the films interposed!

The flowers, their gaiety and fragrancy; the perianthium or empalement of them; their curious foldings in the calyx before their expansion, with a close couch or a concave couch, a single plait or a double plait, or a plait and couch together, or a rowl, or a spire, or plait and spire together; and their luxuriant colours after their foliation, and the expanding of their petals!

The stamina, with their apices; and the stylus (called the attire by Dr. Grew) which is found a sort of male sperm, to impregnate and fructify the seed! At last the whole rudiments and lineaments of the parent vegetable, surprisingly locked up in the little compass of the fruit or seed.

Gentlemen of leisure, consult my illustrious doctor, peruse his Anatomy of Plants, ponder his numberless discoveries; but all the while consider that rare person as inviting you to join with him in adoring the God of his father, and the God who

has done these excellent things, which ought to be known in all the earth.

Signior Malpighi has maintained it with cogent arguments, that the whole plant is actually in the seed; and he answers the grand objection against it, which is drawn from a degeneracy of one plant sometimes in another.

But there is no objection to be made against ocular observation. Shew us, Lewenhoeck, how is it? He will give us to see, a small particle no bigger than a sand, contain the plant, and all belonging to it, all actually in that little seed; yea, in the nux vomica it appears even to the naked eye, and in an astonishing elegance! Dr. Cheyne expresses himself with good assurance upon it: "We are certain that the seeds of plants are nothing but little plants perfectly formed, with branches and leaves duly folded up, and involved in membranes, or surrounded with walls proper to defend them in this tender state from external injuries; and vegetation is only the unfolding and extending of these branches and leaves, by the force of juices raised by heat in the slender tubes of the plant."

Those capillary plants, which all the ancients, and some of the moderns, have taken to be destitute of seeds, are by Bauhinus and others now pronounced spermatophorous.

Cœsius claims to be the first who discovered the seeds of these plants, with the help of a microscope. One Mr. Cole has prosecuted the observation, and is astonished at the small dimensions of the seeds. The boxes or vessels that hold the seeds are not half, perhaps not a quarter, so big as a grain of sand; and yet an hundred seeds are found in one of these.

Sir Thomas Brown observes, That of the seeds of tobacco a thousand make not one grain; (though Otto de Gueric, as I remember, says fifty-two ciphers with one figure will give the number of those which would fill the space between us and the stars!) A plant which has extended its empire over the whole world, and has a larger dominion than any of all the vegetable kingdom.

Ten thousand seeds of harts tongue hardly make the bulk of a pepper corn. But now, as Dr. Grew notes, the body, with the covers of every seed, the ligneous and parenchymous parts of both, the fibres of those parts, the principles of those fibres, and the homogeneous particles of those principles, being but moderately multiplied one by another, afford an hundred thousand millions of atoms formed in the space of a pepper corn. But who can define how many more!

The uses of trees in various works were elegantly celebrated so long ago as when Theophrastus wrote his fifth book of the history of plants. And what stately trees do sometimes by their glorious height and breadth recommend themselves to a more singular observation! The cabbage tree an hundred and forty or fifty feet high, as if it were aspiring to afford a diet to the regions above us; how noble a spectacle!

The trees which are found sometimes near twenty feet, or perhaps more, in circumference, what capacious canoes do they afford, when the traveller makes them change their element! near Scio there is an island called Long-island, on which, as Jo. Pitts tells us, there is a tree of a prodigious size; under it are coffee houses, many shops, and several fountains of water; and it has near forty

pillars of marble and of timber to support the branches of it. It is a tree famous to a proverb all over Turkey.

Even the most noxious and the most abject of the vegetables, how useful are they! As of the bramble Dr. Grew notes, If it chance to prick the owner, it will also tear the thief. Olaus Magnus admires the benefits which the rotten barks of oaks give to the northern people, by the shine, with which they in their long nights direct the traveller. And Dr. Merret celebrates the thistles, and the hop strings, for the glass afforded by their ashes!

The frugal bit of the old Britons, which in the bigness of a bean satisfied the most hungry and thirsty appetite, is now thrown into the catalogue of things which are lost.

The peculiar care which the great God of nature has taken for the safety of the seed and fruit, and so for the preservation of the plant, is by the ingenious Derham considered as a loud invitation to His praises. They which dare shew their heads all the year, how securely is their seed or fruit locked up in the winter in their gems, and well covered with neat and close tunics there! Such as dare not expose themselves, how are they preserved under the coverture of the earth, till invited out by the kindly warmth of the spring!

When the vegetable race comes abroad, what strange methods of nature are there to guard them from inconveniencies, by making some to lie down prostrate, by making others, which were by the ancients called Æschynomenæ, to close themselves up at the touch of animals, and by making the most of them to shut up under their guard in

the cool of the evening, especially if there be foul weather approaching; which is by Gerhard therefore called, the farmer's weather-wiser!

What various ways has nature for the scattering and the sowing of the seed! Some are for this end winged with a light sort of a down, to be carried about with the seed by the wind. Some are laid in springy cases, which when they burst and crack, dart their seed to a distance, performing therein the part of an husbandman. Others by their good qualities invite themselves to be swallowed by the birds, and being fertilized by passing through their bodies, they are by them transferred to places where they fructify. Theophrastus affirms this of the misletoe; and Tavernier of the nutmeg. Others not thus taken care for, do, by their usefulness to us, oblige us to look after them.

It is a little surprising, that seeds found in the gizzards of wild fowl, have afterward sprouted in the earth; and seeds left in the excrement of cattle. The seeds of marjoram and strammonium, carelessly kept, have grown after seven years.

How nice the provision of nature for their support in standing and growing, that they may keep their heads above ground, and administer to our want. There are some which stand by their own strength; and the ligneous parts of these, though like our bones, yet are not, like them, inflexible, but of an elastic nature, that they may dodge the violence of the winds: and their branches at the top very commodiously have a tendency to an hemispherical dilatation, but within such an angle as makes an equilibration there. An ingenious observer upon this circumstance, cannot forbear

this just reflection : A visible argument that the plastic capacities of matter are governed by an all wise and infinite Agent, the native strictnesses and regularities of them plainly shewing from whose hand they came. And then such as are too weak to stand of themselves, it is wonderful to see how they use the help of their neighbours, address them, embrace them, climb up about them, some twisting themselves with a strange convolving faculty, some catching hold with claspers and tendrils, which are like hands to them ; some striking in rooty feet, and some emitting a natural glue, by which they adhere to their supporters.

Indeed all the plants in the whole vegetable kingdom are every one of them so useful, as to rise up for thy condemnation, O man, who dost little good in the world. But sometimes the uses of one single plant are so many, so various, that a wise man can scarce behold it without some emulation as well as admiration, wishing, that if a metamorphosis were to befall him, it might be into one of these. Plutarch reports, that the Babylonians out of the palm-tree obtained more than three hundred several sorts of commodities.

The cocoa-tree supplies the Indians with bread, water, wine, vinegar, brandy, milk, oil, honey, sugar, needles, thread, linen, clothes, caps, spoons, besoms, baskets, paper, and nails ; timber, coverings for their houses ; masts, sails, cordage for their vessels ; and medicines for their diseases ; and what can be desired more? This is more expressively related in the Hortus Malabaricus, published by the illustrious Van Draakenstein.

The Aloe Muricata yields the Americans all that their necessities call for. De la Vega and

Margrave informs us how this alone furnishes them with houses, fences, weapons of many sorts, shoes, clothes, thread, needles, wine, honey, and utensils that cannot be numbered; and Hernandes assures us, that this plant alone furnishes every necessary of life. What a surprising diversity from the cinnamon tree!

Some will have the plantain to be the king of all fruit, though the tree be little more than ten feet high, and raised not from seed, but from the roots of the old ones. The fruit a delicate butter, and often the only food that a whole family will subsist upon. Among the uses of plants, how surprising a one is that, wherein we find them used for cisterns, to preserve water, for the needy children of men! The dropping-tree in Guinea, and on some islands, is instead of rains and springs to the inhabitants. The banduca cingatensium, at the end of its leaves has long sacks or bags, containing a fine limpid water, of great use to the people when they want rains for eight or ten months together.

The wild pine, described by Dr. Sloane, has the leaves, which are each of them two feet and a half long, and three inches broad, so inclosed one within another, that there is formed a large basin, fit to contain a considerable quantity of water (Dampier says, the best part of a quart) which in the rainy season falling upon the utmost parts of the spreading leaves, runs down by channels into the bottle, where the leaves bending inwards again, come so close to the stalk, as to hinder the evaporations of the water. In the mountainous, as well as in the dry and low woods, when there is a scarcity of water, this reservatory

is not only necessary and sufficient for the nourishment of the plant itself, but it is likewise of marvellous advantage to men and birds, and all sorts of insects, who then come hither in troops, and seldom go away without refreshment.

What though there are venomous plants! an excellent fellow of the college of physicians makes a just remark: "Aloes has the property of promoting hœmorrhages; but this property is good or bad, as it is used; a medicine or a poison: and it is very probable that the most dangerous poisons, skilfully managed, may be made not only innocent, but of all other medicines the most effectual."

What admirable effects of opium well smegmatised! even poisonous plants, may be reasonably supposed to draw into their visible bodies that malignant juice, which, if diffused through the other plants, would make them less wholesome and fit for nourishment.

In the delights of the garden it is not easy to hold a mediocrity. They afford a shadow for our celestial paradise. The king of Persia has a garden called paradise upon earth. The ancient Romans cultivated them to a degree of epicurianism. Some confined their delights to a single vegetable, as Cato, doting on his cabbage. The tulipists are so set upon their gaudy flower, that the hard name and crime of a tulipomania, is by their own professors charged upon them; a little odd the humour of those gentlemen, who affected plantations of none but venomous vegetables.

But finally, the vast uses of plants in medicine, are those which we have cause to consider, with singular praises to the merciful God, who so pities

us under the sad effects of our offences. Among the eighteen or twenty thousand vegetables, we have at times a single one, which is a polychrest, and almost a panacæ.

Among the ancients there were several plants that bore the name of Hercules, called heracleum, or heraclea; probably, as Le Clere thinks, to denote the extraordinary force of the plants, which they compared to the strength of Hercules.

Cabbage was to the Romans their grand physic, as well as food, for six hundred years together. Mallows has been esteemed such a universal medicine, as to be called malva omnimorbia.

The six favourite herbs distinguished by Sir William Temple for the many uses of them, namely, sage, rue, saffron, alehoof, garlic, and elder, if they were more frequently used, would no doubt be found vastly beneficial to such as place upon health the value due to such a jewel. The French do well to be such great lovers of sorrel, and plant so many acres of it: it is good against the scurvy, and all ill habits of body.

The persuasion which mankind have imbibed of tobacco being good for us, has in a surprising manner prevailed; what incredible millions have imbibed an opinion, that it is a useful as well as a pleasant thing, for them to spend much of their time in drawing through a pipe the smoke of that lighted weed! In the year 1585, one Mr. Lane carried over from Virginia some tobacco, the first ever seen in Europe; and within an hundred years the smoking of it grew so much into fashion, that the very customs of it, brought four hundred thousand pounds a year into the English treasury.

It is doubtless a plant of many virtues. The

ointment made of it is one of the best in the dispensatory. The practice of smoking it, though a great part of them that use it might very truly say, they find neither good nor hurt by it; yet it may be feared it rather does more hurt than good.

"May God preserve me from the indecent, ignoble, criminal slavery, to the mean delight of smoking a weed, which I see so many carried away with. And if ever I should smoke it, let me be so wise as to do it, not only with moderation, but also with such employments of my mind, as I may make that action afford me a leisure for!"

Methinks tobacco is but a poor nepenthe, though the takers thereof take it for such an one. It is to be feared the caustic salt in the smoke of this plant, conveyed by the salival juice into the blood, and also the vellication which the continual use of it in snuff gives to the nerves, may lay foundations for diseases in millions of unadvised people, which may be commonly and erroneously ascribed to some other original. It is very remarkable, that our compassionate God has furnished all regions with plants peculiarly adapted for the relief of the diseases that are most common in those regions.

Yea, Sclenander affirms that from the quantity of the plants most plentifully growing in any place, he could give a probable guess what were the distempers which the people there were most of all subject to.

Benerovinus has written a book, on purpose to shew that every country has every thing serving to its occasions, and particularly remedies for all the distempers with which it may be afflicted.

Can we be any other than charmed with the goodness appearing in it, when we see the plants every where starting out of the earth, and hear their courteous invitation, feeble man, I am a remedy, which our gracious Maker has provided for thy feebleness; take me, know me, use me, thou art welcome to all the good that is to be found in me! Yea, such are the virtues of the vegetable world, that it is no rare thing to see a whole book written on the virtues of one single vegetable.

How long is Rosenbergius on the rose, in his rhodologia? Whitaker will have the vine to be the tree of life, in his treatise on the blood of it. Alsted has entertained us with a yet greater variety on that plant of renown.

I was going to mention the anatomia sambuci, written by a German philosopher. But I presently call to mind such a vast number of treatises published, each of them on one single vegetable, by the naturalists of Germany, that a catalogue would be truly too tedious to be introduced. If the coral may pass for a vegetable, Garencieres has obliged us with a whole treatise upon it.

But then we have one far-fetched and dear bought plant, on which we have so many volumes written, that they alone almost threaten to become a library. Tea is that charming plant. Read Pecklinus' book de potu theæ, and believe the medicinal and balsamic virtues of it; it strengthens the stomach, it sweetens the blood, it revives the heart, and it refreshes the spirits, and is a remedy against a world of distempers. Then go to Waldschmidt, and you will find it also to brighten the intellectuals.

There is a curiosity observed by Mr. Robinson of Ousby, that should not be left unmentioned; it is, that birds are the natural planters of all sorts of trees; they disseminate the kernels on the earth, which brings them forth to perfection. Yea, he affirms, that he hath actually seen a great number of crows together planting a grove of oaks; they first made little holes in the earth with their bills, going about and about, till the hole was deep enough, and then they dropt in the acorn, and covered it with earth and moss. At the time of his writing, this young plantation was growing up towards a grove of oaks, and of an height for the crows to built their nests in.

In Virginia there is a plant called the Jamestown weed, whereof some having eaten plentifully, became fools for several days; one would blow up a feather in the air, another dart straws at it; a third sit naked, like a monkey, grinning at the rest; a fourth fondly kiss and paw his companions, and snear in their faces. In this frantic state they were confined, lest they should kill themselves, though there appeared nothing but innocence in all their actions. After eleven days they returned to themselves, not remembering any thing that had passed.

My friend, a madness more senseless than that with which this vegetable envenoms the eaters of it, holds thee in the stupefying chains, if thou dost not behold in the whole vegetable kingdom such works of the glorious Creator, as call for a continual admiration.

"The man began to be cured of his blindness, who could say, I see men, like trees, walking. That man is yet perfectly blind who does not see

men, like trees, first growing and flourishing, then withering, decaying and dying.

"The rapæ anthropomorphæ, and some other plants, that have grown with much of a human figure, to be fancied on them, have been odd things. But there are points wherein all plants will exhibit something of the human figure.

The parts of plants analogous to those of the human body, are notably enumerated by Alsted in his Theologia Naturalis. The analogy between their states and ours would be also a profitable and reasonable subject of contemplation. And I hope the revival of the plants in the spring will carry us to the faith of our own resurrection from the dead. And of the recovery which the church will one day see from a winter of adversity; the world from a winter of impiety: the earth shall one day be filled with the fruits of righteousness, however barren and horrid may be its present aspect."

"I will hear these field preachers, their loud voice to me from the earth, is the same with what would be uttered by angels flying through the midst of heaven; fear God, and glorify him!"

"A famous German doctor of philosophy declares, that he found it impossible for him to look upon the vegetable world without these acclamations, Psalm cxxxix, 6. The knowledge of these things is too wonderful for me, it is high, I cannot attain to it."

"The pious Arndt observes, that every creature is enstamped with characters of the divine goodness, and brings testimonies of a good Creator."

"A devout writer treats us with such a thought as this: our God is like a tender father, who,

when the infant complies not presently with his call, allures him with the offer of pleasant fruits to him. Not that the child should stop in the love of the apple, plum and pear, but be by the fruits drawn to the love and obedience of the father that gives them. Our heavenly Father calling on us in his word, gives us also rain from heaven, and fruitful seasons, to engage our love and obedience."

"Among other thoughts of piety upon the vegetable world, some have allowed a room for this; the strong passion in almost all children for fruit; by offering fruit to them, you may draw them to any thing in the world. May not this be a lasting signature of the first sin, left upon the minds of our children! an appetite for the forbidden fruit. When we see our children greedy after fruits, a remembrance and repentance of that sin may be excited in us."

ESSAY XXVII. *Of* INSECTS.

WE are hastening into the animal world. Here we soon find a tribe vastly numerous, called by Pliny insecta, because of their having certain incisures and indentings about their bodies.

The French philosopher does well to rebuke us for calling these imperfect animals, for they want no parts, either necessary or convenient for them; they are complete in their kind, and the divine workmanship is astonishing! Even the poor ephemeron, whose whole period of life is but six or seven hours, who is bred and born, and lives, and goes through all his operations, and expires, and goes into his grave, all within this little period, must not be thrown into a class of imperfect animals; nor may it be said of it, that it is made in *vain*.

Mr. Ray, in his Methodus Insectorum has distinguished the several kinds of insects. Of insects, there are some which do not change their form. Some of these are without feet; these are either terrestrial, produced on the earth or in the earth, (whereto snails may be referred) or within the bowels of animals; or else aquatic, whereof some are greater, which have a peculiar way of moving, by first fixing their head on the ground, and then drawing up their tail towards it; some are lesser, having a different way of crawling; and among these there are both round and flat ones.

But then there are some having feet. There are hexapoda, or six footed ones; of these there are some terrestrial ones, both of a larger sort, and of a smaller: of the smaller, there are about five which molest the bodies of other living creatures; and as many that give not that molestation. There are other aquatic ones.

There are also octapoda, or eight footed ones; of these there are some that have a tail, as the scorpion; and some that have none as the spider; whereof one sort spins no web; three sorts are spinsters. To these add the ticks and the mites.

Yea, there are fourteen footed ones; particularly the three sorts of aselli. More than this, there are twenty-four-footed ones, whose eight fore-feet are lesser ones, and sixteen hinder feet are larger ones.

More than this, there is a sort of thirty-footed ones: but as being tired with specified numbers for the feet of these curious things, the rest we call polypoda, or many footed ones; of these there are some on the land, and others in the water.

Of insects, there are others who do undergo a

change. Though Squammerdam, who has given the best account of these, observes, that there is no real transformation of these, but only an explication of the parts of the animal, which were before latent in miniature, and like the plant in the seed.

Of these there are some, in whose transmutation there is no rest or stop between the old and the new form, and who do not lose their motion at the time of their shifting the pellicula. And there are some, in whom the vermiculus leaving the former shape of the nympha, with which it appeared in the egg, and subsisted without food, now beginning to feed, hath its parts visibly increased and stretched out, and takes the form of a new nympha, which is not without motion, and from thence becomes a flier.

To the former species of transmutation there belong many sorts, thirteen at least; to the second a vast multitude more. And among the rest, the multitudinous armies of butterflies, which being divided into diurnal and nocturnal; of the former sort alone there is about fifty several kinds observed in England.

There is a third species of transmutation, which is a sensible change from a verniculus to a flying insect, but yet with a sensible rest or stop between one form and the other. The flesh-flies belong to this, and some other kinds.

Before we go any further, we will make a pause upon an observation, thus expressed by Mr. Barker in his Natural Theology; for it is upon a matter which occurs in the view of all creatures, that now remain for our contemplation; yea, the vegetables too have themselves exemplified it.

"Whence is it that these two natural principles of self-preservation and self-propagation, are so inviolably founded in the nature of all living creatures, even those that have no reason, as well as those that have; both which are necessary to the subsistence of the universe? May not we hence easily argue, that surely this was done intentionally for such an end? And if intentionally, then it is done by reason; and if by reason, it must be by his reason that first made the universe."

Dr. Gorden adds to the assurances which all the inquisitive before him have given us, that no insects are bred of corruption, but all of eggs. He also observes, that the females of all flies put their spawn in or near those places where the erucas, which are hatched out of them are to have their food. He observes likewise, that there is a kind of gluten, by which the females fasten their eggs to the bearing buds of trees, at such a rate, that the rain cannot wash them off. And he observes, these eggs will not be hurt by the greatest frost that can happen.

Mr. Andry takes notice of a mistake in the ancients, who denied breath to the insects on the score of their wanting lungs; for insects have a greater number of lungs than other animals. The ancients also thought that the insects had no blood, because many of them had not a red liquor like ours; but this too was a mistake, it is not the colour, but the intent of the liquor that is to be considered in this case. It was likewise the belief of the ancients, that the insects had no hearts; whereas our microscopes now convince us of the contrary. And the silk-worms particularly have a continued chain of hearts, from the head almost

to the extremity of the tail. And it is the number of lungs and hearts that occasions those insects to give signs of life a long while after they are divided into several parts.

Mr. Poupart affirms, that the earth-worms and the round tailed worms, which are found in the intestines of animals, as also snails and leeches, are hermophrodites; but such worms as become flies are not so, rather they are of no sex, but are nests full of animals.

The spontaneous generation of insects has at last been so confuted by Redi, Malpighi, Squammerdam, Ray, and others, that no man of sense can any longer believe it. Indeed such a spontaneous generation would be nothing less than a creation. That all animals are generated of parent animals, is established from observation and experiment.

If an insect may be equivocally generated, then, why not sometimes a bird, yea, a man? Or why no new species of animals now and then? For there is as much art shewn in the formation of those, as of these. Dr. Cheyne assures us, nobody now-a-days, that understands any thing of nature, can imagine, that any animal, how abject soever, can be produced by an equivocal generation, or without the conjunction of male and female parents, in the same or in two different individuals. And there are very few who have considered the matter, but what own that every animal proceeds from a pre-existent animalcule, and that the parents conduce nothing but a convenient habitation to it, and suitable nourishments, till it be fit to be trusted with light, and capable of enjoying the benefits of air. There is nothing in

the animal machine, but an inconceivable number of branching and winding canals, filled with liquors of different natures, going a perpetual round, and no more capable of producing the wonderful fabric of another animal, than a thing is of making itself. There is besides in the generation of an animal, a necessity that the head, heart, nerves, veins and arteries, be formed at the same time, which never can be done by the motion of any fluid, which way soever moved.

Great God, thou art the father of all things; even the father of insects, as well as the father of spirits; and thy greatness appears with a singular brightness in the least of thy creatures!

Concerning frogs generated in the clouds, there has been a mighty noise; the thunder scarce makes a greater! But Mr. Ray says well, it seems no more likely than the Spanish gennets begotten by the wind, for that has good authors too. He adds, he that can swallow the raining of frogs, hath made a fair step towards believing that it may rain calves also; for we read that one fell out of the clouds in Avicen's time. Fromondus' opinion, that the frogs which appear in great multitudes after a shower, are not indeed generated in the clouds, but are coagulated of dust, commixed and fermented with rain water, is all over as impertinent. It is very certain that frogs are of two different sexes, and have their spermatic vessels; and their copulation is notorious, and after the spawn must be cast into the water, where the eggs lie in the midst of a copious gelly; then must appear a feetless tadpole, in which form it must continue a long while, till the limbs grow out, and it arrives to the perfect form of a frog.

To what purpose all this, if your way, gentlemen, (Fromondus, and the rest) may suffice?

Frogs appearing in such multitudes upon rains, do but come forth upon the invitation which the agreeable vapour of rain water gives to them. And for some such reason we are commonly entertained with such armies of them in the cool summer evenings, that we wonder where they have been lurking all the day. Monsieur Perrault, upon the dissection of the falling frogs, which the equivocal gentlemen so teaze us with, found their stomachs full of meat, and their intestines of excrement. The inquisitive Mr. Derham, on his meeting with frogs in a prodigious number, crossing a sandy way just after a shower, pursued the matter with his usual exactness, and he soon found the colony issue from an adjacent pond, who having passed through their tadpole state, and finding the earth moistened for their march, took the opportunity to leave their old latibula, where they had now devoured their proper food, and seek a more convenient habitation. Or what if we suppose them, at least in their spawn, carried up into the clouds by the sun, and kept there till grown into the state wherein they fall down from thence, as it has been affirmed they have on vessels at sea?

As to the worms and other animals bred in the intestines of man and beast, "I think it may be proved, that the vast variety of worms found in almost all the parts of different animals, are taken into the respective bodies by meats and drinks." Even the maggots which grow in the back of the common caterpillar, are by their parents lodged there, as a proper apartment for them. Toads found in the midst of trees, and in stones, when

they have been sawn asunder, no doubt grew of a toad spawn, which fell into that matter before the concretion thereof.

The vulgar opinion, that the heads or clothes of uncleanly people do breed lice, or that mites are bred in cheese, is a vulgar error: all such creatures are produced of eggs laid in such places by their parents; nature has endued them with a wonderous acuteness of scent and sagacity, whereby they can, though far distant, find out such places, and make towards them; and though they seem so slow, yet it has been found that in a little time they will march a considerable way to find out a convenient harbour. Here Mr. Ray makes a pause of religion; says he, "I cannot but look upon the strange instinct of this noisome and troublesome creature the louse, of seeking out foul and nasty clothes to harbour in, as an effect of divine Providence, designed to deter men and women from sordidness and sluttishness, and provoke them to cleanliness. God himself hates uncleanness, and turns away from it, Duet. xxiii, 12, 13, 14. But if God requires, and is pleased with bodily cleanliness, much more is He so with the pureness of the mind. Blessed are the pure in heart, for they shall see God!"

The eyes of insects have in them what is very admirable. Their great necessity for accurate vision is, in the reticulated cornea of their eyes, admirably provided for; it is a most curious piece of lattice-work, in which every foramen is of a lenticular nature, and enables the creature to see every way without any time or trouble; probably every lens of the cornea has a distinct branch of the optic nerve ministering to it.

Spiders are mostly octonocular; some as Mr. Willoughby thought, senocular. Flies are multoculor, having as many eyes as there are perforations in their corneæ. The greatest part of the head of that prædatious insect, the dragon fly, is possessed by its eyes.

Though we say, as blind as a beetle, Mr. Leuenhoeck has discovered at least three thousand eyes in the beetle.

Insects have their antennæ, by which they not only cleanse their eyes, but also guard them; their eyes being fitted mostly to see objects at a distance, these feelers obviate the inconvenience of their too rashly running their heads against objects that may be very near to them.

And many of them are, as Mr. Derham observes, surprisingly beautiful. The mechanism in those which creep is curious. What can exceed the oars of the amphibious insects, which swim and walk? Their hindmost legs are made most nicely, with commodious flat joints and bristles, on each side thereof towards the ends, serving for oars to swim; and nearer the body are two stiff spikes, to enable them to walk, as they have occasion.

An incomparable provision is made in the feet of such as walk or hang on smooth surfaces; divers of these, besides their acute and hooked nails, have also skinny palms on their feet, which enable them to stick on glass, and other smooth bodies, through the pressure of the atmosphere. The great strength and spring in the legs of such as leap, is very notable; and so are the well made feet and strong talons of such as dig.

Admirable the faculty of some which cannot

fly, to convey themselves with speed and safety, by the help of their webs, or some other artifice that renders their bodies lighter than the air. How pleasantly do the spiders dart out of their webs, and sail away by the help thereof; whereof Dr. Lyster and Dr. Hulse were some of the first who made a discovery? There seems to be a hint of their darting in Aristotle, and in Pliny; but the ancients knew nothing of their sailing. Some other little animals may have their ways of conveyance as unknown to us, as heretofore has been that of the spiders; creatures found in new pits, and holes in the tops of houses, where they were never bred by any equivocal generation. The green scum on the surface of stagnant waters, which is nothing but prodigious numbers of animalcules; how came they there? And when gone, where do they go? What can be better contrived than the legs of insects, most incomparably fitted for the intended service? Or than their wings, distended and strenghtened with the finest bones, and these covered with the lightest membranes, whereof some are adorned with the most beautiful feathers; for the elegant colours of moths and butterflies are owing to neat feathers on their wings, that are set in rows with great exactness, and all the good order imaginable? And some are provided with articulations, for their wings to be withdrawn, and folded up in cases, and again readily spread abroad upon occasion: scarabs and other that have elytra, are thus accommodated. That their bodies may be kept steady and upright, there is the admirable artifice of pointels and poises, under those which have no more than two wings, whereas the four winged ones have no such things: these poises in

the bipenated insects are for the most part little balls, that are set at the top of a slender stalk, which they can move every way at pleasure to obviate vacillations. If one of the poises be cut off (or if the four-winged have lost one of their secondary or auxiliary wings) the insect will fly as if one side over balanced the other, till it fall to the ground.

How minute, but how astonishingly curious, must be the joints, the muscles, the tendons, and the nerves, necessary to perform the motions of these marvellous creatures! These things concur even in the smallest animalcules, and such as cannot be seen without our microscopes.

Among the celebrated pieces of human art, there was the cup that Oswald Nerlinger made of a pepper corn, that held twelve hundred little ivory cups, all gilt on the edges, and having each of them a foot, and yet afforded room for four hundred more. But Mr. Derham justly celebrates the more stupendous art, which plainly manifesteth the power and wisdom of the infinite Contriver of the inimitable fineries in the bodies of our little insects; they must have eyes, a brain, mouth, stomach, entrails, and other parts of an amimal body, as well as legs and feet: and all these must have their necessary nerves and muscles; all these are covered with an agreeable tegument, whereof how neat the imbrications and other fineries! All this curiosity many times lying in a body much smaller than the smallest grain of sand. A drop of water is a sort of an ocean to them! Mr. Derham in a drop of the green scum upon water, a drop not bigger than a pin's head, saw no less than an hundred frisking about. How vastly many

more in a drop of pepper water! how vastly many more in a drop of the Leuenhoeckian examination! Dr. Harris affirms, that not only in black pepper water, but also in water wherein barley and oats, but especially wheat, hath been steeped for about four or five days, he hath seen prodigious numbers of them. Great God, we are amazed!

The Jews have a foolish notion, though advanced by a Rabbi Solomon, upon the Egyptian plague of lice, that the devil has the dominion of no creature which is less than a barleycorn. Indeed a man who by humility shrinks himself into less than the light dust of the balance, may take the comfort of the notion. But then in philosophy, what a mighty army of animals less than a barleycorn are found under the dominion of the glorious God, who also has all the devils as much under his command as the least of these. I have read of a fly in a chain. Beelzebub is no more before the almighty Maker of the flies, and all other insects.

The sagacity observable in the generality of insects, for their provision against the necessities of the winter, is never enough to be admired.

Some having fed and bred themselves up to the perfection of their vermicular state in the summer months, then retire to a place of safety, and there throw off their nympha, and put on their aurelia state for all the winter, in which they have no occasion for any food at all; this is done by all the papilionaceous, as well as divers other tribes.

Others, in their most perfect state, are able to subsist in a kind of torpitude, without any food at all; being at no action, they are at no expense, but can lie and sleep whole months without any

sustenance. It is remarkable that it is not any stress of weather which drives them into their intended retirement, but they go to it in the proper season, towards the end of summer. It is also remarkable, that every species betakes itself to a convenient receptacle, whereof there is a vast variety, where the frost cannot come to them.

There are others who need food in the winter, and it is astonishing to see what a foresight their glorious Creator has given them to lay up accordingly.

One of these providers is the bee, reckoned by Aristotle among the civil people. Prepare now for a scene of wonders. Every colony of bees has a king. This majestical bee has a sting, which he can use without loosing it; but his majesty rarely finds occasion for it. The common bees which have their four wings and six legs are divided into bands, which have their officers, all working for the good of the whole, and as long as they live. But then there are drones, which are larger than they, and are servants and nurses under the honey bees, in hatching their brood. A bee, as Rusden observes, the first day of his flying abroad is an exquisite chymist, or at least a diligent surveyor and collector of the honey dews, provided by heaven for him on the leaves of the plants in the field, which he lays up in convenient cells, and there preserves it in a covering of wax, as foreseeing that a winter is coming. How indefatigable the pains of these industrious and marvellous creatures! If they have no king, they pine, they die, they yield themselves a prey to robbers; but they will not bear two. Butler observes, they abhor polyarchy, as well as anarchy. Their king

oppresses none, is a benefactor to all; so their loyalty to him is inviolate. His place of abode makes a court, a noble retinue of bees attends him.

They have the orders of their king for all the work they do; and they never swarm without his orders. The chief cause of their swarm is the want of room. He usually goes himself with them, as in view of a more flourishing state, and leaves his decaying and unpleasant kingdom, with the noisome old combs, to such successors as he has left alive. If the old one dies in his going forth, they return home to the prince whom they had relinquished. And the king sometimes gives his consent to a second swarm, though there be no lack of room, out of his respect to some of his royal lineage. In their hives they are just to one another, though the fear of being robbed makes them kill any strangers that break in upon them. Colonies are sometimes engaged in wars; the king usually orders the battle, animating them with his voice, and like a general, for whose defence they unanimously expose themselves: They neither give nor take any quarter, and they distinguish one another by their smelling. Spurt any thing among them that may make them smell all alike, and their hostility ceaseth. The king is the only male among the bees. Each particular cell in the honey-comb is a matrix. The king walks from one cell to another, and injects a seed into each of them; the honey bees mix with it a generative matter, which they have lodged there, and add water to it, and cover it with wax, which is not opened till the young bee opens its way out of it. The drones are also begotten by the king in like manner, but on a generative matter something

different, and in deeper cells. The drones are for no purpose, but only to lie at home close to the combs, where the young bees are breeding, and hatch the young brood, as a capon does the eggs assigned to him. Hence the time for breeding the drones is deferred till near the fall of the honey dews, because they would have the use of them at as little charge of feeling as they can. But such is the nature of the drones, that if the bees do not kill them, as they generally do, when they can be no further serviceable, they do by the coldness of the season in September die of themselves.

But now how many moral instructions would the commonwealth of bees afford to a mind willing to be instructed of God, by the ministry of this mysterious insect! Honest Purchas has with an imitation of it gathered no less than three centuries of them; and yet these are but a few of the things which these preachers would advise us of: I will single out but this one peculiar document from them for myself, which Pliny takes notice of: nothing hinders their industry but bad weather.

Another of these providers is the ant, whereof the wise man says, they are exceeding wise; a people not strong, yet they prepare their meat in the summer.

Sir Edward King having been curious in examining their generation, wonders to find them lying in multitudes on their eggs, which they industriously gather together, by way of incubation. He wonders to see them in the morning bringing them up towards the top of the bank, and for the most part on the south side of it; but at night, especially if it be cool, or if likely to rain, you may

dig a foot before you can find them. Indeed all is wonderful.

There is the field ant and the wood ant; the field ant feeds upon small seeds. They have their leaders and rulers, which they follow along their little paths in exact order, and return the same way; they all go out light, but all return home heavy laden, with their burdens on their backs. The wood ant feeds upon leaves. You may see sometimes great paths made by them, three or four inches broad, and as beaten as the high ways; they march stoutly under such loads, that you cannot see their bodies; a path looks perfectly green with them. In two months of the year they take wing, and fly abroad in the warm sun, to take their pleasure, after the fatigue of their labour is over. And how unparalleled the tenderness, the diligence, the foresight, of these little animals for the safety of their young! It is very diverting to see how they carry about their young ones, and expose themselves to any dangers, rather than leave their young ones exposed; and how they remove them from one place to another, as they find occasion.

Sometimes the ants in the Indies have nests most artificially placed between the limbs of huge trees, and these nests as big as a hogshead; here is their winter habitation. They will ransac strangely for provisions, and in mighty troops, which all follow wherever the foremost goes. Mr. Derham well observes; "That it is evident, that the great wisdom discernible in this little animal, is owing to the infusions of the great Conservator of the world; because either this wisdom or forecast is an act of the animal itself, or of a

being that hath wisdom: but the animal being irrational, it is impossible it can be its own act, but it must be derived or received from some wise being. And who! what can that be but the infinite Lord, and conservator of the world!"

An ant hill, is a seat of a very curious contrivance. Johnston makes it an article of his Thaumatography, and says very truly, the structure of no city is better. If you read the description of the quadrangular city, four feet long and a foot wide, the streets wisely laid out, the convenient granaries provided, the civility of the citizens to one another, as Aldrovandus has given it, you would see nothing in any Strabo more entertaining.

I wonder not that the wisdom of God sends me thither: Go to the ant thou sluggard; may I learn her ways and be wise.

But we are passing into a theme, whereon there is no end of the wonders! The care of the insects about their offspring. Singular their povidence for their young, in finding or making fit receptacles for their eggs or seed, where they may enjoy a sufficient incubation, and have ready an agreeable and sufficient food for their education.

They to whom fish is proper food, lay their sperm in flesh; from which nursery of maggots, S. Redi has for ever banished the old whimsey of anomalous generation, by incontestible experiments. Others, to whom the fruits or leaves of vegetables are a food, find a repository there. Some take this tree, some take that herb; and one family still always the same. If the cochineal were not accommodated with a fruit like a prickly pear, which opens (after the flower which protected it, is by the heat of the sun scorched away,) when

the small red insects are come to maturity, and would die and rot for want of more food, if the Indians did not now come to shake them out; gentlemen, where would you be supplied with your so much esteemed scarlet?

Others require a greater degree of warmth in their lodging, and those look out the bodies of larger animals, that they may be lodged there. Many, if not most sorts of birds, have their lice in their feathers; and several sorts of beasts have peculiar lice in their hairs, all distinct from the two sorts wherewith man is infested. It has been pretended that the ass is free, and an odd reason assigned for it; but it has been rather supposed from a passage in Aristotle, the chronology whereof will not well suit with the odd reason I refer to.

Some work themselves into the very scales of the fishes. They find them in the very stomach of cod fish. The sheep complains of them in the nose; the kine have them on their backs; the horses in their intestines. Those in the heads of deer are often mentioned by ancient writers. Worms of many yards long are bred in the legs of men, and in other parts of their bodies; in their tongues, their gums, and their noses, as it is reported in our Philosophical Transactions; in their eyes, and their eyebrows, as in the German ephemerides. Mouffet and Tyson inform you what worms the stomach and bowels of men have often breeding in them. Lately in my neighbourhood a poor man reaching to vomit, a monstrous worm thrust up one end of itself, which the man seizing on, fell to pulling of it, as a fisherman pulls up his line, and pulled till the worm lay in an enormous heap; whence being drawn into its length and

measured, the worm, in the full extent of it, made about one hundred and fifty feet long. Yea, Dr. Lyster affirms true caterpillars to have been vomited from thence. And Mr. Jessop affirms true hexapods to have been also thrown up with vomit. Entertain unquestionable accounts from Germany, and you will see toads, frogs and lizards, cast up from a human stomach, no doubt from the drinking of their spawn. The livers and kidneys of animals have had their worms: yea, Verzascha has found them (without a metaphor) in the brains of men; probably they were laid in the laminæ of the nostrils, and gnawed their way into the brains through the os cribriforme.

Wierus found them divers times in the gall bladder of persons whom he had opened. In divers fevers the blood has been found strangely vermiculated, as Kircher and several others have upon examination reported; so one worm kills another! Verminous collections are found in the small pox, as Lange and Borellus testify; and in pocky scabs there are incredible multitudes of them.

Others who make themselves nests by perforations in the earth, or in some wood, or in combs of their own building; it is admirable to see how they lay in, and seal up the provisions that will be necessary for their young ones there. So divers ichneumons carry in maggots, which they take from the leaves of trees, which they sagaciously put up close into their nests. Aristotle says they carry in spiders too.

Their nidification is astonishing. When their eggs are on the leaves of plants, or other materials on the land, how commodiously are they laid!

always carefully glued on, with one certain end lowermost, and handsome juxta positions. When in the water, in what beautiful rows! In a gelatine matter so fastened, as to prevent its dissipation. Single out but Pliny's instance of the gnat, a contemptible animal, the story of his proceedings would give you a thousand astonishments! They who must perforate hard bodies, to make their lodgings there, have their legs, feet, mouth, yea, their whole bodies, very strangely accommodated to the service.

But for them who build or spin their nests, their art, as Mr. Derham expresses it, justly bids defiance to the most ingenious artist among men so much as tolerably to copy them. The geometrical combs of some, the terrestrial cells of others; the webs, nets and cases of divers. The very spider knows its lesson.

There is a natural glue afforded by the bodies of several to consolidate their work. The wasps have this, as well as the tinea vestivora, the cadew-worm, and several others; what Goedart also observes of his eruca, this can be by some darted out at pleasure, and woven into silken balls. Mr. Boyle mentions an oval case of a silk-worm, which a person of his acquaintance drawing out all the silken wire that composed it, found it above three hundred yards, and yet weighed no more than two grains and an half. That wonderous insect, the silk-worm has no eyes, but how fine its performances. Let the historia singularis of them, written by Libavius, be perused, it will be found a collection of wonders. Good God, shall thy silk-worm adorn me, and shall he not instruct me too! There is another worm, which would at

least learn this of him, to spin out of his own bowels, from his own experience and his own meditation, such things as may be useful to those to whom they shall be communicated. But, O vain person, proud of the silken attire that is rusling upon thee; is it possible that in a little worm thy pride should find a nourishment!

There are others of these little animals which make nature itself serviceable to their purpose, and make the vegetation of trees and herbs the means of building their little habitations. They build in the galls and balls of the oak, the willow, the brier, and other vegetables, and are furnished with a piercer, to prosecute their business. Among these we will single out what the ichneumon-fly does to the leaf of the nettle. The parent insect, with a stiff setacious tail, terebrates the rib of the leaf when tender, and makes way for its egg into the very pitch or heart thereof, and lays therewith some juice of its body, which will pervert the regular vegetation of it. From this wound arises a small excrescence, which, (when the egg is hatched into a maggot) grows bigger as the maggot increases, and swells on each side the leaf, between the two membranes, and extends itself into the parenchymous part thereof, till it has grown as big as two grains of wheat. In this mansion there lies a small, white, rough maggot, which turns to an aurelia, and afterwards to a very beautiful, green, small, ichneumon-fly.

A peculiar artifice, and so far out of the reach of any mortal understanding, that here must be, as Mr. Derham justly pauses upon it, the concurrence of some great and wise Being, that has from the beginning taken care for the good of the ani-

nal! The formation of these cases is quite beyond the cunning of the animal itself, but it is the act partly of the vegetable, and partly of some virulence in the juice or egg of the animal reposited in the vegetable.

It is a just thought of one well skilled in cosmology, that men themselves, and much more other creatures, may do many things which aptly serve to some certain end whereof they have no consideration. Creatures may be directed and constrained by a strong fancy which they have of various works, and various actions that belong to them. Well, but who has imprinted it? It is the great God who will have such works to be done. Great God, shall we contrive what service of thine thy nobler creature man may thereby be helped to! an excellent philosopher concludes: the divine reason runs like a golden vein through the whole leaden mine of brutal nature.

There is one thing more to be added: that the numbers of insects and vermin may not be too offensive to us, Providence has ordained many creatures, especially such as are in superior orders, to make it their business to destroy them, especially when their increase grows too numerous and enormous. As in the Indies, where they are sometimes exceedingly punished with ants, there is the ursus formicarius, whose very business is to devour them. Hideous armies of worms do sometimes visit my country, and carry whole fields of corn before them, and climbing up trees, leave them as bare as in the middle of winter. Our wild pigeons make this the season of their descent, and in prodigious flocks they fall upon these robbers, and clear the country of them.

The destruction and death of animals does proclaim the fame of the divine wisdom in adjusting it.

The locusts, that have sometimes proved so devouring a plague, do also prove a dish to the people that suffer from them. In a Voyage round the World, I read, that in the East Indies, when these creatures come in great swarms to devour their fruits and herbs, the natives take them with nets, and parch them over the fire in an earthen pan, on which their wings and legs would fall off, and their heads and backs turn red, but their bodies being full, would eat moist and sweet enough, and their head a little crackle in one's teeth; a dish that people might subsist upon: though the condition of the Acridophagi, mentioned by Diodorus, and by Strabo, would not encourage one to be confined to it.

Even the more noxious insects and vermin are such, that we may consider in them the finger of God. The sufferings they inflict upon us, may be considered as the scourges of God upon us for our miscarriages, and be improved as excitations to repentance. I have read somewhere a passage to this purpose: "I would carry on the matter to so much of watchfulness, in my apprehending opportunities for thoughts of repentance, that the provocations that may happen to be given to my bodily senses at any time, shall provoke such thoughts in my soul. If I happen to lodge where any insect or vermin assaults me, it shall humble me. I will think I have been one among the enemies of God in the world. These uneasy creatures are part of the armies which the Lord of Hosts employs, and with some contempt, *against* his enemies!"

The worms which, especially in places where the salt and fresh water meets, do in such horrid swarms eat into the bottoms of ships, and render them even like honey-combs; the coasts that are not infested with them, ought to acknowledge the favour of Heaven in it; and the merchant and mariner that suffers by them, ought to consider what rebuke of Heaven upon their dealings or doings may lie at the bottom of such a calamity.

How wretched would our condition be, if we were constantly infested with flies, like the poor winking people of New Holland! To be exempted from the mischiefs which the justice of God sometimes inflicts on people who do not acknowledge Him, is what calls for our acknowledgments of his goodness.

If the Lord of Hosts please to single out from his armies, whereof there is no number, no other legions than those of insects, how would they embitter, and even extinguish our lives. Locusts alone make whole nations tremble: worms have destroyed kings; and flies have scattered kingdoms. But then the reverse: O cantharides, how many millions of lives are continually saved by your epispastic applications! God is to be acknowledged in the good which is done by a green fly to the children of men.

Mr. Terry tells us, that among the Persees in the East Indies they profess this devotion: that the first creature of sense and of use which they behold in the morning, they employ still as a remembrancer to them all the day following, to draw up their thoughts in thanksgiving to the Almighty God, who hath made such a creature for our service. My God, shall the Pagan rise up and con-

demn the Christian! If we should not from the view of thy creatures have our hearts drawn up to thy praises, we should to our confusion find it so.

"For what ends are all these little creatures made? Most certainly for great ends, and for such as are worthy of a God. The exquisite artifice which is conspicuous in the make of these creatures, does proclaim a marvellous and matchless wisdom in the Maker of them; and Wisdom will make nothing in vain. Though the more special uses of these creatures be as yet unknown to us, the only wise God sends to us this advice concerning them: What I do thou knowest not now, but thou shalt know hereafter."

"However, this we know now; for these and all creatures this end is great enough, that the great God beholds with pleasure the various and curious works of his hands. Behold a sufficient end, as well for a world as for a worm, that the infinite God may with delight behold his own glories in the works which his hands have wrought. My readers, let us come to a consort in the doxology; O Lord, thou hast created all things, and for thy pleasure they are and were created. The great God has contrived a mighty engine, of an extent that cannot be measured, and there is in it a contrivance of wonderous motions that cannot be numbered. He is infinitely gratified with the view of this engine in all its motions, infinitely grateful to Him so glorious a spectacle! when it becomes grateful to us, then we come into some communion with him. I will esteem it a sufficient end for the whole creation of God, that the great Creator may have the gratification of beholding his own admirable workmanship. And I will esteem

it a part of the homage I owe to his eternal Majesty, to be satisfied in such an end as this."

"I will transfer this meditation to the exercises which are to fill a life of piety. Have I not reason enough, motive enough, to abound in all the exercises of a pious life, even the most secret of them, and a guard upon the frames and thoughts of my heart within me? The great God is the beholder of my whole behaviour, he knows the way that I take; and I choose the things that please him in what I am now doing."

Finding myself now entered into the animal world, I take this opportunity to insert and pursue an observation of the acute Dr. Cheyne; which is, that the production of animals is a thing altogether inconsistent with the laws of mechanism: from whence I infer, that it must be from something superior to them.

For first, the blood is by the force of the heart squeezed from the left ventricle, through the arteries, to the extremities of the body, and is thence returned by the veins into the right ventricle, thence by the arteria pulmonalis into the lungs; from the lungs by the vena pulmonalis again into the right ventricle. The motion of the heart is caused by the nervous juices mixing with the blood, in the muscular part thereof; and these nervous juices are both derived from the blood, and forced into the muscular part of the heart, by the motion of the heart itself, the texture of the containing vessels, and perhaps by the pulsation of the arteries upon the nerves of the brain. Here now, the heart is the cause of the motion of the blood in the arteries; and the motion of the blood in the arteries urging their juices through the nerves, is the cause of the motion of the heart:

which is a plain circulation of mechanical powers, a perpetual motion, a thing unknown to nature! An epicurean cannot contrive a water machine, wherein the water should move the machine, and the machine move the water, and the same water continually return in a circle to move the machine.

Great God, it is thy immediate influence on the powers of nature in me that keeps my heart in motion. Oh, that I may love thee and serve thee with all my heart! In thee I live! to glorify thee, should be the business of my life.

Again, in all animals how small, how fine the organs! how indefinite the number of them! Sensation is performed by the mediation of organs arising from the brain, and continued through the part affected. Now there is not the least imaginable solid part of the vessels or muscles but what we find sensible; wherefore the number of organs that convey sensation must be inconceivable! Nutrition is also performed by organs, through which a supply is conveyed to the place to be nourished. Now there is no part of the body but what may be increased or lessened; so then in every individual point of the body there is the termination of organs, through which a nourishment may be conveyed. Furthermore, the canals do all augment, and may all decay; and therefore every assignable part of these canals must be the termination of some secretory duct, separating a fluid fit for the repairing of their losses, and these again must have others to repair their losses; and how shall we conceive where to stop? Moreover, the most exquisite glasses can discover nothing in the several parts of the vessels and muscles, but canals amazingly slender; the better the glasses,

the more of these capillary pipes are discovered. In short, all the solid parts of the body are nothing but either tubes to convey some fluid, or threads in bundles, tied by others that surround them, or going from one fibre to another, or spread into thin membranes; but each of these how inconceivably minute! the doctor does not scruple to say, infinitely!

O infinitely Great God, I am astonished! I am astonished! For all these things hath my hand made, saith the Lord.

ESSAY XXVIII. *Of* REPTILES.

LET us now handle the reptiles, which are a sort of animals that rest one part of their body on the earth, while they advance the other forward.

In our way of doing it we shall take up serpents, and they shall not hurt us. The meanest of these, viz. the earth worm and the spiral motion of it, is admired as well as described by Dr. Tyson. The motion of reptiles is extremely curious. Their food and their nest lies in the next clod, plant, or hole; or they can long bear hunger and hardship. So their sinuous motion, performed with as much art as what is in the legs or wings of other creatures, and as curiously provided for, is found sufficient for the conveying of them. There is abundance of geometrical neatness and niceness in the motion of serpents; their annular scales lie cross their belly, contrary to those in the back and the rest of the body: the edges also of the foremost scales lie over the edges of the following scales; and every scale has a distinct muscle, one end of which is tacked to the middle of the scale, the other to the upper edge of the following scale.

Snails have neither feet nor claws, but they creep with an undulating motion of their body; on which Dr. Lyster has written: and by a slime emitted from their body, they adhere to all kinds of superfices.

The motive parts of caterpillars are admirably contrived, not only to serve their progression, but for gathering of their food. The spine, and muscles co-operating with the spine, in such as have bones; and the annular and other muscles in such as have none; are incomparable contrivances.

The magnitude whereto some serpents have grown, is prodigious. Bochart will astonish you with a collection of relations found in antiquity concerning serpents, and particularly dragons, of a most enormous magnitude. Gesner too will quote us authors for some so large, that the little book I am now writing will afford no room for them.

Yea, Suetonius affirms, that one was exposed by Augustus, which was no less than fifty cubits long. Dio comes up with him, and affirms, that in Hetruria there was one that was fourscore and five feet long, which, after he had made fearful devastations, was killed with a thunderbolt. Strabo out-does him, and affirms, that in Cœlo-Syria there had been one which was a hundred feet long, and so thick, that a couple of men on horseback, on each side of him, could not see one another. Yea, one that was an hundred and twenty feet long, was killed near Utica by the army of Regulus.

"Ye dragons, whose contagious breath
People the dark retreats of death,
Change your dire hissings into heavenly songs,
And praise your Maker with your forked tongues."

The poisonous tribes have been made an objection against the divine providence, as being destructive to the rest of the world.

The poison of a viper is found by Dr. Mead, on a microscopical examination, a parcel of small salts, nimbly floating in the liquor, but quickly changed, and shot out into crystals, of an incredible tenuity and sharpness, with something like to knots here and there, from which they seemed to proceed: it lies in a bag in the gums, at the upper end of the teeth; these teeth are tubulated, for the conveyance of poison into the wound which they make. Galen says, mountebanks did use to stop these perforations of the teeth, before they would let spectators behold the vipers to bite them. Let it be considered, that the venomous creatures have their great medicinal uses; we see a treacle brought out of a viper; the viper's flesh cures leprosies and obstinate maladies. The gall of a rattle-snake (which we take out of him in the more early months of his yearly appearance, and work into troches with chalk or meal) is a rich cordial and anodyne, for which purpose I have often taken it, and given it: it invigorates the blood into a mighty circulation, when fatal suppressions are upon it; it is highly alexipharmic, and cures quartan agues. And yet this rattle-snake, such a venomous wretch, that if he bite the edge of an axe, we have seen the bit of steel that has been bitten, come off immediately, as if it had been under a putrefaction.

The very steam of serpents in the famous La Grotta delli Serpi, at Sassa in Italy, celebrated by Wormius from Kircher, and strangely discovered by a leper happening to sleep there, does wonderous things.

Moreover, there is no poison without an antidote. It is observed, the bruised flesh of the venomous creatures applied to their bites, cures the venom of them. But, as Mr. Derham observes, "There would be no injustice in God for to make a set of such noxious creatures, as rods and scourges, to execute the divine chatisements on sinful men." He adds, "I am apt to think, that the nations which know not God are the most annoyed with those noxious reptiles, and other pernicious creatures."

There is a strange story related and asserted by Franzius, A. D. 1564, vast armies of serpents appeared in Hungary, and occupied their fields of corn; and when the people were with a particular contrivance by fire going to destroy them, one that was larger than the rest lifting up his head, articulately cried out, "Desist, we do not come to destroy the fruits of the earth of our own accord, we are sent by God." If the story should be but a fable, yet the moral is wise and good.

It may be they that have been thought venomous, have not had in them so much venom as has been thought. Sir Theodore Mayern laughs at the poison of a toad, and says, it is no worse than a frog; he had himself without mischief eaten several. Mr. Robinson of Cumberland, who offers it as a conjecture, that the venomous creatures lick up the venom of the earth, which, if it were diffused, might be more dangerous than their bite or sting. The same person observes concerning the crawling worm, which is despised, as the most useless among all the creatures of God, that the earth abounds with a gross, fat, luxuriant slime at the time when these vermin are engendered, and

which they feed upon; this, if not sucked up, and contracted into the bodies of these diminutive animals, but were diffused through the grass and herbage, would occasion murrains in beasts, and perhaps diseases in men, whose diet is much upon herbage. A worm now makes a pause, and adores the Divine workmanship appearing in the constitution of his brethren.

What amazing effects follow on the bite of the tarantula! the patient is taken with an extreme difficulty of breathing, and heavy anguish of heart, a dismal sadness of mind, a voice querulous and sorrowful, and his eyes very much disturbed. When the violent symptoms which appear on the first day are over, a continual melancholy hangs about the person, till by dancing or singing, or change of air, the poisonous impressions are extirpated from the blood, and the fluid of the nerves: but this is a happiness that rarely happens; nay, Baglivi, this wicked spider's countryman, says, there is no expectation of ever being perfectly cured. Many of the poisoned are never well but among the graves, and in solitary places; and they lay themselves along upon a bier, as if they themselves were dead: like people in despair, they will throw themselves into a pit; women, otherwise chaste enough, cast away all modesty, and throw themselves into very indecent postures. There are some colours agreeable to them, others offensive, especially black; and if the attendants have their clothes of ungrateful colours, they must retire out of their sight. The music with the dancing which must be employed for their cure, continues three or four days; in this vigorous exercise they sigh, they are full of complaints;

like persons in drink, they almost lose the right use of their understanding: they distinguish not their very parents from others in their treating of them, and scarce remember any thing that is past. Some during this exercise are much pleased with green boughs of reeds or vines, and wave them with their hands in the air, or dip them in the water, or bind them about their face or neck; others love to handle red cloths and naked swords. And there are those who, upon a little intermission of the dancing, fall a digging of holes in the ground, which they fill with water, and then take a strange satisfaction in rolling there. When they begin to dance, they call for swords, and act like fencers; sometimes they are for a looking-glass, but then they fetch many a deep sigh at beholding themselves. Their fancy sometimes leads them to rich clothes, to necklaces, to fineries, and a variety of ornaments; and they are highly courteous to the by-standers that will gratify them with any of these things; they lay them very orderly about the place where the exercise is performed, and in dancing please themselves with one or other of these things by turns, as their troubled imagination directs them.

How miserable would be the condition of mankind, if these animals were common in every country! But our compassionate God has confined them to one little corner of Italy; they are existing elsewhere, but no where thus venomous, except in Apulia. My God, I glorify thy compassion to sinful mankind, in thy restraints upon the poisons of the tarantula!

But who can behold the dispositions of the poor tarantulates, and not behold at the same time with

horror, a lively exhibition of the follies whereto vicious people are disposed? Perhaps the thought well pursued would give such an illustration of the venom that befools, depraves, and enslaves vicious people, as to lead us into some very right notions of the methods, wherein the evil spirits, to whose conduct they have resigned themselves, do, through a just judgment of God, operate upon them.

Vicious people, if you are not so tarantulated, that it will fright you to look into a looking-glass, bethink yourselves, and in the condition of the miserables that are stung with a tarantula, behold as in a looking-glass your own behaviour and confusion.

"That the least and the worst of creatures may do man the service of leading him to God, a renowned writer has demonstrated, in singling out the example of a toad. A gentleman saying, that in every one of the creatures he could see invitations to the praises of God, one asked him, what! in a toad? He made this good answer; that a good God has advanced me above the baseness and venom of that contemptible animal."

ESSAY XXIX. *Of* FISHES.

THE fishes of the sea shall declare to thee. Let us become divers, and visit the watery world; there we shall see, as Mr. Derham says, a various, a glorious, an inexhaustible scene of the Divine power, wisdom, and goodness.

The variety of the creatures that are the inhabitants of the waters is very considerable. Pliny in the eleventh chapter of his thirty second book, reckons up one hundred and seventy six kinds of

them: indeed he is very short in his account. Our christian Pliny, the excellent Ray, raises the number of the fishes to five hundred, excluding the shell-fish; but of the shell-fish more than six times the number, and yet he thinks there may be but half the species of the fishes yet known to us.

Mr. Willoughby says Aristotle's division of the fishes is the best; and is divided into three kinds, the cetacious, the cartilaginous, and the spinous. He gives us a catalogue of ninety three several sorts of English fishes. The shape of their bodies, long and slender, or else very thin, is admirably accommodated to their action of swimming, wherein they are to divide the waters.

The air-bladder, wherewith most of the fishes are furnished, is what cannot be beheld without astonishment. By this they poise their bodies, and keep them equiponderant to the water; without it they would fall to the bottom, and lie grovelling there, as it has been found, when the wind-bladder has been broken. By contracting or dilating this bladder, they are able to sink or raise themselves at their pleasure, and continue in any depth of water they please.

Fishes are sensible of sounds, but whether they hear, or only feel the sounds, is very much disputed.

Their fins, made of gristly spokes, connected by membranes, like our fans, are furnished with muscles for motion, these do partly serve them for progression, but chiefly to hold the body upright: when these are cut off, as they were by Borelli, they waver to and fro, and when they die, their belly turns upwards.

The great strength by which they dart them-

selves forward with an incredible celerity, lies in their tails; almost the whole musculous part of their bodies is bestowed upon them, to assist the vibration thereof. How fishes row themselves by their tails, and other curiosities relating to swimming, you may read in Borelli's ingenious discourse *de motu animalium.*

It is remarkable to see how fishes have the centre of gravity always placed in the fittest part of their bodies, which is a point of great consideration in their fluid element.

Consider the food of these animals; they neither chew their meat in their mouths, nor grind it in their maws: but in their stomach they are furnished with a dissolvent liquor, which does corrode their food, and reduce it, skin, bones and all, into a chylus or cremor; and yet it is very marvellous, the taste can perceive in this liquor nothing of acidity: it will manage flesh as aqua-fortis does metals, and yet no sensible sharpness in it!

But where shall they find their food? Lord, these wait all upon thee, that thou mayest give them their meat in due season: what thou givest them, they gather; thou openest thine hand, they are filled with good. How rich a promptuary is this unlikely element! From the largest leviathan which playeth in the seas, to the smallest mite in the lakes and ponds, all are plentifully provided for; as is manifest (which Mr. Derham notes) from the fatness of their bodies, and the gaiety of their aspects and actions.

There is a germination of divers aquatic plants in the waters; the waters are also a sort of a matrix to many animals, particularly insects, not only such as are peculiar to the waters, but

also many pertaining to the air and land; who, by their near alliance to the waters, delight in being about them, and so become a prey to the inhabitants thereof. Dr. Schuyl mentions the horror of the water turned into blood at Leyden, from nothing but the infinite swarms of pulices upon it; besides these, what mighty shoals do we find of lesser animals there, which the greater feed upon!

What a vast supply of our food have we in sucking the abundance of the seas? How many millions of the fish are every year fetched out of their element, and interred in the hungry bowels of men? Some of these very delicious, particularly the white fish, whereof such infinite shoals in the vast lakes of North America, which has this very singular property, that all sorts of sauces do but spoil it; it is always eaten, either boiled or broiled, without any manner of seasoning.

You, gentlemen, who think your own country of England worth visiting with your travels, as methinks you should before you go abroad, find the little river Trent in Staffordshire affording thirty several sorts of fishes; you will be ready to affirm of it, as the Hungarians did of their Tibiscus, two parts are water, the third is fish.

My God, when in our necessities we ask of our father a fish, our heavenly Father feeds us, how agreeably, how plentifully!

As the smallest animals are bred in the waters, witness those in pepper water, so are the largest; those of the cetaceous kind are there.

Pliny mentions the balænæ of the Indian sea, which were nine hundred and sixty feet long;

and he mentions whales that were six hundred feet long, and three hundred and sixty broad, which came into a river of Arabia. In the second chapter of his ninth book he offers a reason why the largest animals are bred in the sea.

But I love to pass from him to a more trusty and modern Pliny, the industrious Ray; and we will now see something of his remarks upon these belluæ marinæ: the tail in these has a different position from what it has in all other fishes; it lies parallel to the horizon in these, and it is perpendicular in the rest; hereby it supplies the use of the hinder pair of fins, which these creatures lack; and it serves both to raise and sink their body at their pleasure. It is necessary that these creatures frequently ascend to the top of the water to breathe, and therefore they should be furnished with an organ by which their ascent and descent might be facilitated. The turning of their bodies in the water they perform like the birds, by the motion of one of their fins while the other is quiescent. It is very remarkable that their whole body is compassed round with a copious fat which we call the blubber, whereby their bodies are poised, and rendered equiponderant to the water, and the water also is kept off at some distance from the blood, the immediate contact whereof might else have had some chilling force upon it; it serves likewise, as our clothes do for us, to keep the fish warm, in reflecting the hot steams of their body, and so redoubling the heat thereof: hence they can abide the greatest cold of the northern seas, to which they chiefly resort, not only for the quiet which they enjoy there, but because the northern air, which is

more fully charged with the particles which we suppose to be nitrous, and that are the aliment of fire, is fittest of all to maintain their vital heat in that activity, which may be sufficient to move such an unwieldy bulk as theirs. The stupendous magnitude of these animals! Thou antitype thereof, among the poets which adorn our age, describe them to us.

> While the vast whale takes in the deep his place,
> Prince of the waters and the finny race;
> Rolling in sport, the billows he removes,
> And, like a floating isle the ocean shoves:
> Now in his weedy court he lies at ease,
> Now spouts against the skies exhausted seas.

Let what I gave you of the nine hundred and sixty feet pass for a Plinyism; and so what Basil in his hexæmeron reports of whales equal in size to the greatest mountains, let the censure of Brierwood pass upon it, as an intolerable hyberbole: we will write more sober things. Passing by what Ælian affirms of the whale being five times beyond the largest elephant, we find Rondeletius assigning him sometimes a thirty six cubits of length, and eight of height. Dion is a grave, as well as an old writer, and he reports a whale coming to land out of the German ocean, sixty feet in length, and twenty in breadth. But Gesner, a later, affirms a whale to have landed near Tinmouth Haven, in the year 1532, which was ninety feet in length, and the breadth of his mouth six yards and an half, and his belly of such a compass, that one standing on the fish, and slipping into his belly, very narrowly escaped being drowned there.

But then, if we may take Hartenius for a voucher, among the twenty several kinds of whales

by him enumerated, he reckons one sort that is thirty ells long, and hath more than seventy teeth, so large as to make handles of knives and other instruments. He reckons another sort that is forty ells long, and overwhelms vessels that come in his way. He proceeds to some eighty ells long, and some ninety. All these proclaim the grandeur of their great Creator.

Even in the cold sea too, what a warmth of parental affection do the old ones express for their young ones, and how distinguishing! when the seals are hundreds of thousands of them lying in a bay coming out of the sea, they bleat like sheep for their young; and though they pass through hundreds, yea, thousands of other young ones before they come to their own, yet they will suffer none but their own to suck them. Even the sea monsters draw out the breast, they give suck to their young ones. Monstrous parents, that are without natural affection! these inhabitants of the sea with open mouth cry out against you.

"I remember a Crassus, of whom it is reported, that he so tamed a fish in his pond, as to make him come to him at his calling; verily, I shall have a soul deserving his name, and be more stupid than the fish, if I do not hear the calls which the fish give to me to glorify the God that made them; and who has in their variety, in their multitude, in their structures, their dispositions and sagacities, displayed his glories. The papists have a silly and foolish legend of their St. Anthony preaching to the fishes; it will be a discretion in me to make the reverse of the fable, and hear the fishes preaching to me, which they do many truths of no small importance. As

mute as they are, they are plain and loud preachers; I want nothing but an ear to make me a profitable hearer of them.

"It is a good wish to be in virtute delphinus, to use the despatch of the quick dolphin in all good purposes.

"Though it is the way of the sea for the greater to devour the lesser, and the wisdom of heaven is conspicuous in it; yet I deprecate this way of all the earth: for indeed the fish, who devour not those of their own particular kind, therein condemn the cursed rapacity too often seen among the children of men.

"To catch fish is an employment whereby many support themselves, a diversion wherewith many refresh themselves; in managing this fishery what an opportunity for many useful reflections! How happy we, if taken in the nets of salvation! we are so when effectually persuaded to the embracing of our Saviour, and of his religion.

"Alas! the ministers of the gospel now fish, not with nets, but with rods; and after long angling, and baiting, and waiting, how few are taken!

"In the temptations to sin and vice which are offered to me, I see the hooks with which the destroyer proposes to take me, that I may be thrown into the perdition of ungodly men. My God, let not the Satanic baits have any power over me.

"How suddenly is the fish caught and killed, and with what a surprise, when the poor animal has not the least thought of such a fate coming upon him! one moment sporting, taken the next; he pulled away, his fellows not at all regarding it!

ıe was a wise man who long since took notice of his; Man knoweth not his time: as the fishes hat are taken in an evil net, so are the sons of nen. My God, help me to think seriously of leath every day, as not knowing but it may be ny dying day.

" At our tables we are now welcome to all the ish we can fairly come at, whether they have any ins or scales or no; but methinks it gives a spe-ial relish to the dish, as it is a dish which my admirable Saviour sometimes tasted of.

ESSAY XXX. *Of* BIRDS.

THE birds now invite us to soar and sing with them the praises of our God.

These ought immediately to follow the fishes, and are either land fowl or water fowl. Of the land fowl, some have crooked beaks and talons, whereof some are carnivorous, called birds of prey. And some are also frugivorous, called by the general name of parrots.

Others have their bills and claws more straight; of which there are some of a larger size, which cannot fly at all.

Some are of a middle size, and have either a larger or longer bill; some feed promiscuously, some only on fish, some on insects: or a smaller and shorter bill, of which some have a whiter flesh, others a blacker.

Some are of a lesser size, called the small birds; which are either the soft beaked, that feed mostly on worms or flies; or the hard beaked, that feed mostly on seeds.

The water fowl are either such as frequent the waters for their food, these are all cloven footed,

and generally have long legs, and those naked for a good way above the knees, that they may the more conveniently wade in the waters; or they are such as do swim in the waters, the most of these are whole-footed: some have but three toes on a foot, but most of them four; these either all connected by intervening membranes, or more usually with the back toe loose. Most water fowls have a short tail.

In birds the shape and make of their body is incomparably adapted to their flight; before, sharp, to pierce and make their way through the air, and then rising to their full bulk by gentle degrees.

Their feathers, how artificially placed, for facilitating the motion of their body! were they placed any other way (as they would have been if mere chance had placed them) they would have gathered air, and been an incumbrance to the passage of their body through the air; whereas in the neat order they are now placed, they are like a boat new dressed and cleaned, making its passage through the waters. At the same time they have the security of an admirable clothing in them, with a soft and warm down next to their body, but those next to the weather of stronger consistence, and closed most curiously. And then there is a most surprising accession to all this in the art, with which these animals dress their feathers, and the wonderous oil-bag with which they are for this purpose accommodated. There is usually one gland (Mr. Willoughby sometimes found two) in which there are divers little cells, ending in two or three larger ones, which lie under the nipple of the oil-bag; this

nipple is perforated, and being pressed or drawn by the bird's bill or head, emits a liquid oil in some, an unctuous grease in others, which being put on their feathers, contributes to their nimble gliding through the air.

How commodiously their wings are placed! they that fly much, or have most occasion for their wings, have them in the very best part imaginable, to balance their body in the air, and give them a swift progression. Alter their equipoise, by cutting a wing, or hanging a weight, and how they reel! Such as have as much occasion for swimming as for flying, have their wings therefore set a little out of the centre of their body's gravity; and for such as have more occasion for diving than for flying, these for that reason have their legs more backward, and their wings more forward.

The incomparable curiosity of every feather! the shaft, hollow below, that it may be the stronger and lighter; above a pith filling it, which is also both strong and light; the strength marvellous! the vanes, how nicely gauged! broader on one side, narrower on the other, in both contributing to the progressive motion of the fowl, and closeness of the wing. The vanes of the flag feathers of the wing, the edges of the exterior bending downwards, of the interior upwards, by which means they lie close to one another when the wing spreads, and not one feather misses its full impulse on the air; yea, the very sloping of the tips of these feathers is a nicety to be wondered at.

Let an eye assisted with glasses view the textrine art of the plumage, and, as Mr. Derham,

who has given us a more particular account of it, justly says, it will be found so exquisite, that it cannot be viewed without admiration.

"My pen, thou art brought from the wing of a bird; thou wast one of the feathers, which thou art now writing of! how surprising an engine! how surprising, how extensive, how powerful thy operations in the world! never shall my pen be employed in any thing but the service of the glorious God, to whom I am indebted for it."

Admirable the apparatus of the strong, but light bones in the wings! the joints which move so as to answer all occasions! the strength of the pectoral muscles in birds is greater than in any things not made for flying. Borelli observes, that the pectoral muscles in men are very small, and they do not come up to the fiftieth part of all the muscles; but in birds the pectoral muscles are very large. For which cause Willoughby observes, that if men would propose to prosper in their vain project for flying, their wings must be fastened not to their arms, but their legs, the muscles being much stronger there.

The tail of the bird, which has been thought a sort of a rudder, serves wonderfully to assist the ascent and descent of the bird in the air, and obviate the vacillations of the body and wings. The flight performed according to the strictest rules of mechanism! the untaught artist gives a motion to his wings, than which the acutest mathematician could not give one more agreeable. Blind philosopher, canst thou see no God in all this? View next the feet and legs, which minister to their other motion. Both of them very light, for their easier transportation through the air.

In water-fowl how exactly do their feet and legs correspond to their way of living! Some of them have their legs pretty long that they may wade in the waters; in this case their legs are without feathers a good way above their knees, their toes also are broad: and in the mudsuckers two of their toes are somewhat joined, that they may not easily sink in walking upon boggy places. Those that are whole-footed, or have their toes webbed together, have their legs generally short, which for swimming is most convenient; and it is pretty to see how artificially they gather up their toes and feet when they take their stroke, and as artificially again extend or open their feet when they drive themselves forward in the waters.

Rapacious birds have hooked beaks, strong, sharp, and pointed talons, fitted for the rapine they are so intent upon, and for tearing the flesh that falls into them; and they have robust and brawny thighs, for striking down their prey.

By the way; of this kind there is a sort of white crows (we must believe some who tell us this!) which they call king-carrion-crows; and it is affirmed, that when a great number of crows are assembled about a carcass, if a king-carrion-crow be among them, he falls on first, and none of the rest will taste the least morsel till he has filled himself and withdrawn. I hope these crows do no hurt by breaking in upon a paragraph that is treating upon other matters, especially if they effectually teach us, that the want of good manners will never want a condemnation.

Birds that climb, as the wood-pecker kind, how fitted for the purpose! Their thighs very strong, their legs very strong, but yet very short;

their toes, two forwards, two backwards, and so closely joined, that they may firmly lay hold on the tree: a hard, and a stiff tail, bending downwards, on which they lean, and so bear themselves up in climbing.

How conveniently are the legs of birds curved, for their easy perching, roosting, and rest; and to help them up upon their wings in taking their flight, and then to be so tucked up to the body as not to obstruct the flight!

It is admirable that such birds as are fin-toed are naturally directed and carried to the water, and swim there; thus ducklings, though hatched and led by a hen, when they come near a pond of water, they go, though they never saw such a thing before, and though the hen clucks and calls to keep them out.

Aristotle observes, there is no flier but what has feet as well as wings, a power of walking or creeping upon the earth; it is because there is not always a sufficient food to be had for them in the air, nor could the birds take any rest, for without feet they could not perch on the trees; and if they lit on the ground, they could not again easily raise themselves; and where could they sit, hatch, and breed their young? The story of the bird of paradise, received even by the learned in the former age, is now found a fable; that bird has legs and feet, and those great and strong, and armed with talons, as being a bird of prey.

The bill of birds, how suited for gathering food, and other uses? The eye, how commodiously situated! (It is, by the way, a thing so remarkable, that nothing less than astonishment can be the result of the observation; that the fowls in

their tribes have their centinels, especially in the night. The watchfulness of the scart is true to a proverb: one, by surprising the centinel, has caught three hundred in a night.) And the ear, which would obstruct the flight of it, were it like that of other animals; the inner ear, largely described by Mr. Derham, is a contrivance that is a very amazing one. Willis admires the points wherein the brain of birds and fishes agree, differing from the brain of man and beasts. The swan can continue half an hour under water without any danger of choaking.

Read Blasius and Coiter, and admire the tongue of the wood-pecker, especially the sharp, horned, bearded point, and the glewy matter at the end of it, the better to stab and stick into the little maggots, and to draw them out of the wood.

The several ways the birds have of purveying for their food, call for our consideration as we go along: but how can they be considered without some surprise of pleasure at the view of them. Among all these, that of the man-of-war bird, mentioned by Dampier, is very singularly diverting. He sees a bird called a booby, and flying at him, gives him a blow, which causes him immediately to disgorge the fish he has in his crop; and this he seizes on, perhaps before it can in its fall reach the earth or water. "It is in effect what men do to one another, when the justice of Heaven uses them to make seizures on one another's possessions. Have not the French in the late and long wars, been men-of-war birds, on the English nation!"

Wonderful the provision in the bill, for judging the food! it has peculiar nerves for the purpose.

These are smaller and less numerous in them that have the assistance of their eye: but they are more numerous and thickly branched about, to the very end of the beak, in such as hunt for their food out of sight, in water, in mud, or under ground. Flat-billed birds, grope for their meat; have three pair of nerves that come into their bills, whereby they accurately distinguish what may be proper for their food.

Shall we stop a moment, and consider how useful the carnivorous birds of prey become, even in prosecuting their voracious inclinations? If the number of lesser birds were not by their means lessened into such a proportion, those lesser birds would overstock their feeding; and then also, should those lesser birds, which are so numerous, die of age, they would leave their carcasses to rot upon the ground, corrupt the air, and become insupportable.

Dr. Grew observes, both birds and beasts having one common use of spittle, are therefore furnished with the parotid glands, which help to supply the mouth with it; but the wood-pecker, and other birds of that kind, because they prey upon flies which they catch with their tongue, in the room of the said glands, have a couple of bags filled with a viscous humor; a sort of natural bird-lime, which being by small canals, like the salival, brought into their mouths, they dip their tongues in it; and with the help of this, they attack and master their prey.

Pass from the mouth to its near ally the stomach. It is admirable in its duplicity; one to soften, another to digest! Admirable in its variety, suited to a diverse diet: membranous in some that

are carnivorous; musculous, with a strength agreeable, where grain must undergo a comminution.

The gizzard has a faculty of grinding; to which purpose the bird swallows rough stones, which when grown smooth, it throws up again as useless. Dr. Harvey says, this grinding may be heard in eagles and some other fowls, if you lay your ear close to them when their stomachs are empty.

In birds there is no mastication or comminution of the meat in the mouth; but in such as are not carnivorous, it is immediately swallowed into the crop or craw, or at least a kind of ante-stomach, where it is moistened and mollified by proper juices, from the glandules there distilled, then transferred to the gizzard. Their lungs adhere to the thorax, and have little play; which is a good provision for their steady flight. Wanting the diaphragm, instead of it they have diverse bladders, made of thin transparent membranes, with pretty large holes out of one into the other. These membranes contain air, and are also braces to the viscera. The lungs have large perforations, through which the air has a passage into the belly. Doubtless the body is hereby made more or less buoyant, and their ascent or descent facilitated.

Their necks, how proportioned to the length of their legs! Indeed, they that must search out their food in the waters, have them so long, that when their heads are extended in flight, they cause a due equipoise and libration of the body upon the wings. The inspection of these things compel us to confess the glorious Maker of them all.

The nidification of birds, a thing how full of curiosity: they find out secure places, and very

proper ones; where their young may lie safe and warm, and have their growth promoted. But then, with what an artificial elegance are some of their nests prepared? Human skill could hardly imitate it. Among other curiosities of nidification, I will mention one that is observed by pigeons of my own country. They build their nests with little sticks laid athwart one another, at such distances, that while they are so near together as to prevent the falling through of their eggs, they are yet so far asunder, that the cool air can come at their eggs. And the reason for this architecture of their nests is this; their bodies are much hotter than those of other birds; and their eggs would be perfectly addled by the heat of their bodies in the incubation, if the nests were not so built, that the cool air might come at them to temper it.

We have seen the nest of an Indian bird composed of the fibres of certain roots, which were so curiously interwoven, that it could not be seen without astonishment. These nests they hang on the ends of the twigs of the trees, over the water, to secure their eggs and young from the ravages of apes, and other beasts, that else would prey upon them. They are justly enough called subtle jacks.

What shall we say of the flamingos? They build their nests in shallow ponds, where there is much mud; which they scrape together into little hillocs, like islands, appearing out of the water about a foot and a half high from the bottom. They make the foundation of these hillocs broad, bringing them up tapering to the top, where they leave a small hollow pit, in which they lay their eggs; and when they either lay or hatch their

eggs, they stand all the while, not on the hilloc, but close by it, with their legs on the ground, and in the water, resting themselves on the hilloc, and covering the hollow nest upon it with their bodies. Their legs are very long, and building as they do upon the ground, they could neither draw their legs conveniently into their nests, nor sit down upon them otherwise than by resting their whole bodies to the prejudice of their eggs or young, were it not for this rare contrivance.

The incubation, for which this tribe of animals is remarkable, opens a new scene of wonders. The egg with its crusty coat is admirably fitted for it. Here we find one part provided for the formation of the body before it is grown to any considerable dimensions, another for its nourishment afterwards till the bird be able to shift for itself. But then the accurate bracing of these parts, by which they are kept in their due place, must be a designed, as well as a curious piece of workmanship. They are separated by membranes.

The chalazæ, (which because formerly thought the sperm of the cock was called the treddles,) are, as Harvey says, as it were the poles of this microcosm, and the connexions of the membranes. But as Mr. Derham observes, they serve only to keep one and the same part of the yolk always uppermost, let the egg be turned which way it will. The chalazæ, it seems, are specifically lighter than the whites in which they swim; and being braced to the membrane of the yolk, not exactly in the axis of the yolk, but somewhat out of it, it causes one side of the yolk to be heavier than the other: so that the yolk being by the chalazæ made buoyant, and kept swimming in

the midst of the two whites, is by its own heavy side kept with the same side always uppermost, and probably this uppermost side is that on which lies the cicatricula. It is affirmed, that our hens once in every day of their incubation turn their eggs, without ever turning of one more than once, or leaving any one unturned. This is for a service which they understand not themselves. The conveyance of what colours we please to the fowl that is hatching, by painting the eggs is a curiosity.

That birds must lay eggs, is a sensible argument of a divine Providence, designing to preserve them, and secure them, that there might be a greater plenty of them, and that the destroyers might not straiten their generations. Had they been viviparous, if they had brought forth a great number at a time, the burden of their womb would have rendered them so heavy, their wings could not well have served them: or if they had brought forth but one or two at a time, they would have been troubled all the year long with bearing or feeding their young. The conveniency consulted in oviparous animals, is one of Dr. More's triumphs over atheism. Of these eggs he makes an antidote against that hellish poison.

Dr. Cheyne will more particularly assure us, we know that the eggs of animals are only an uterus for a little animal, furnished with proper food, and fenced from external injuries: and we know likewise that all the effects of incubation are only to supply a proper degree of heat, which may make the congealed fluids to flow, and more easily pass into the nourishing channels of the included animalcule. On this occasion he goes on, we

are sure that all the transformations of insects and other animals, are nothing but the expansion of their parts, and the breaking of the membranes that folded them up, by the augmentation of those parts; and all the several figures they put on, are owing to the several membranes in which they are involved. His conclusion is what I was wishing for: It is impossible duly to consider these things, without being wrapt into admiration of the infinite wisdom of the divine Architect, and contemning the arrogant production of chance and jostling atoms.

As Mr. Derham observes, what a prodigious instinct is it, that birds, and only they, should betake themselves to this way of generation! How should they be aware that their eggs contain their young, and that they have in their power the production of them? What should move them to betake themselves to the nests, and there with delight and patience abide the due number of days? And when their chickens are hatched, how surprising is their art, and care, and passion, in providing for them, until they are able to shirk for themselves.

A remark of Mr. Ray is worthy to be introduced here. It would be on many accounts inconvenient for birds to give suck; and yet no less inconvenient, if not altogether destructive to the chicken, upon exclusion all of a sudden, to make so great a change in its diet, as to pass from a liquid to a harder food, before the stomach be consolidated, and by use habituated to concocting it, and its tender and pappy flesh fitted to be nourished by what shall be strong and solid; and before the bird be by little and little accustomed

to using his bill in the gathering of it up, to which it comes not very readily: therefore there is a large yolk provided in every egg, a great part of which remains after the chicken is hatched, and is inclosed in its belly, and by a channel made on purpose, received by degrees into the intestines, and serves instead of milk, to nourish the chicken for a considerable time; which nevertheless in the mean time feeds itself by the mouth, a little at a time, and gradually more and more, as it gets a more perfect ability.

I will add a curiosity relating to the pigeons, which annually visit my own country in their seasons, in such incredible numbers, that they have commonly been sold for two-pence a dozen; yea, one man has at one time surprised no less than two hundred dozen in his barn, into which they have come for food, and by shutting the door, he has caught them all. Among these pigeons the cocks take care of the young ones for one part of the day, and the hens for the other. When they are taken, we generally take but one sex at a time. In the crops of the cocks, we find about the quantity of half a gill of a substance like a tender cheese-curd: the hens have it not. This curd flows naturally into their crops, as milk does into the dugs of others creatures. The hens could not keep their young ones alive when first hatched; but the cocks fetch up this thickened milk, and throw it into the bills of their young ones, which are so nourished with it, that they grow faster, and fly sooner than any other bird among us. None but the cocks which have young ones to care for, have this curd found in their crops. Kill one of those cocks, and all the

young ones pine away and die in the nest, notwithstanding all that their dams can do for them. See sirs, and be instructed!

All birds lay a certain number of eggs, or near that number, and then betake themselves to their incubation: but if their eggs be withdrawn, they will then lay no more. When they have laid such a number of eggs as they can conveniently cover, brood, and hatch, then they begin to sit. This is not because they are necessarily determined to such a number: for hens, for example, if you let their eggs alone, when they have laid fourteen or fifteen, they will begin to sit; whereas if you daily take away their eggs, they will go on to lay five times that number. This holds not only in domestic birds; and so, as Mr. Ray observes, it cannot be thought the effect of cicuration and institution: But the like was observed also by Dr. Lester, in swallows.

But although almost the whole tribe of birds, do produce their young by incubation, there is a marvellous deviation from it in some few families which do it in a more novercal way, and without any trouble at all, only by laying their eggs in the sand, exposed to the heat of the sun. This instinct of the ostrich particularly, who leaveth her eggs in the earth, and warmeth them in the dust, is ascribed unto God, who supplies the want of concern in the parent animal another way.

It is a surprising thing, which the observing Ray has mentioned. Such oviparous creatures as are long-lived, have eggs enough at first conceived in them, to serve them for many years laying; probably for as many as they are to live: allowing such a proportion for every year, as will

serve one or two incubations. But insects which are to breed but once, lay all their eggs at once, have they ever so many. He says most justly, chance cannot govern it.

The scarcity of the voracious and pernicious birds, and the plenty of the mansuete, and useful, and more desirable, is to go among the matters of our wonderment. And so must the swift motion of such whose food is to be sought in distant places, and in different seasons; the slow motion and short flight of others more domestic; and the awkwardness of fome to flight, whose food is be got near at hand.

Who feeds the young ravens when they cry? Birds which feed their young in the nest, though they bring but one morsel of meat at a time, and have seven or eight young, which at the return of their dams, with equal greediness, hold up their heads and gape, forget not one of them, they feed them all. Good Mr. Ray well observes, it is beyond the possibility of a mere machine to perform such a thing as this.

With what an impetuous desire of sitting are the birds inspired, while it is called for! After the young are hatched, for sometime they do almost constantly brood them under their wings, lest they should suffer by any inclemency of the season; all this while how hard they labour to get them food! almost pining themselves to death rather than that their young should want any thing! With what courage are they inspired in this time, to venture their very lives in defence of them, and even fly in the face of a man that shall molest their young, which they never do in their own defence! These things are contrary to the instinct of self-

preservation, and are eminent pieces of self-denial. Mr. Ray says well, they must needs be the works of providence for the upholding of the world! These pains are bestowed upon a thing which takes no notice of it, makes no amends for it, never acknowledges it with thankfulness; and when the young one is grown old enough to shift for itself, the old one takes no further care of it. The words of Mr. Robinson on this occasion are agreeable: "She does she knows not what, but yet it is what ought to be done by the most exquisite knowledge; hence it is conclusive, that something else has knowledge for her, even the Creator and contriver of all things, who is the omniscient and omnipotent God." At the same time how remarkable to see, that poultry and partridge, and other birds, at the first sight know the birds of prey, and make a sign of it with a peculiar note to their young ones, who thereon hide themselves.

We are surprised at what Ramus tells us of the wooden eagle and the iron fly, made by Regiomontanus; the former of which flew forth of the city, met the emperor a good way off, salutud him, and returned with him; the latter, at a feast, to which he invited his friends, flew out of his hand, fetched a round, and flew back to him again before the astonished beholders. Du Bartas employed his poetry on these curiosities.

But what! no honours, no praises due to that infinite God, who hath with so much art contrived all the variety of birds, and accommodated every part of them within and without in such a manner, that there is not so much as a feather misplaced, redundant, or defective.

In Deuteronomy xiv, there is a bird called ra-

cham, which signifies mercy. The Talmudists say, that when this bird appears, the mercy of God and his Messiah is then coming to the world. Verily, in every bird that flies in the world, there is a display of the Divine goodness, as well as power and wisdom. I wish that, in the reigning dispositions of benignity and compassion among mankind, racham were making her appearance.

Birds and beasts which are domestic, or the most useful, are most prolific; there are more hens than kites, more geese than swans. A crane, which is but poor meat, hatches no more than two eggs in a year: several sea-fowls but one. The pheasant and partridge, excellent meat, and easily come at, hatch fifteen or twenty. The more valuable which lay fewer at a time, sit the oftener, as the dove. Thus, if it were not out of place to observe it here, there are more dogs than foxes; more cats than lions. The sheep feeds and breeds in all countries much alike.

Of wild fowl, which are the most useful, are gregarious, which render them the more visible and audible to us, and the more plentiful game. And for our more quiet possession of things that are most useful, they are naturally marked, when there is occasion for it. Wild fowl, fishes and other creatures, which are not fitted by nature for man's possession, have only such distinguishing marks as belong to the whole species; but of the domestic, as poultry, horses, dogs and cats, not only the species, but the individuals have their marks.

"My great Saviour has given me this direction: Consider the fowls of the air. But is it possible to consider them without continual wonders at the

Divine workmanship appearing in them. Wonders to be articulated and modulated into endless praises of their glorious Creator. Methinks the sweet notes uttered by many tribes of them invite me to their consort."

"I know not what to make of a relation published a few years ago, but so well attested, that a pious and worthy man wrote a large treatise upon it, entitled, *vox corvi*, which affirms, that a raven perching on the top of a steeple, and thence turning towards a quarrelsome neighbourhood, was heard very audibly and articulately to utter these words, *Look into the third of the Colossians and the sixteenth.* But this I know, Ask the fowls of the air, and they shall tell thee. There needs no genius to take a possession of our birds, that we may hear from them the admonitions of piety, and exhortations to believe and adore an infinite God."

"The providence of the glorious God, in the propagation and sustentation of the fowls, is admirable; it extends to ravens and sparrows; and shall I imagine myself excluded from the care of that Providence. Mr. Dodd ventured upon the difficulties and contingences of a married life, when he saw a hen with her chickens provided for. O unbelief, I command an eternal silence to thee. Shall the birds of season bring with them a condemnation of my inadvertency, to my fittest opportunities for the doing and getting of good!"

"There are images of many virtues in birds, of which I would endeavour an imitation, and therein glorify the God that speaks to me by them; among these I would especially pitch upon two. Teach me, O stork, how gratefully to treat my

Parent; shew me, O dove, how lovingly to treat my consort."

The man who learns all the good of which the birds remind him, and then lives to the God, whose work and whose voice he discerns in the birds, this man shall be a phœnix, and the traditions of the ancients no longer a fable.

ESSAY XXXI. *Of* FOUR-FOOTED ANIMALS.

WE proceed to the animals that are perfect, hairy, and walking upon four. These quadrupeds are either hoofed or clawed.

Of the hoofed or ungulate, some are whole-hoofed, of which it is observed that none have horns, nor have the males any appearance of breasts: there are four of these. Others are cloven-footed; of these there are two divisions. There is the bisculate kind, which is also subdivided. There are the ruminant. Some of these have perpetual horns. Whereof there are six of the bull-kind, five of the sheep-kind, eleven of the goat-kind. Others have deciduous horns; these are the deer-kind, whereof eight sorts have been reckoned up.

Of those who do not chew the cud, there is only the swine-kind, whereof there are five sorts reckoned up. And then there is the kind whose hoof is cloven into four divisions; we know five of these, but we know no rumination in any of them.

Of the clawed or digitate; there is one sort whose claws adhere to one another, covered with one common skin, but with obtuse nails, that stick out round the margin of the foot; this is the elephant, who must pass for anomalous.

There is another sort, which has only two claws;

namely, the camels, which, though they have no horns, do ruminate, and have the four stomachs of the horned ruminants.

A third sort includes those whose feet are divided into many claws, with broad nails on them: this is the ape-kind, whereof there is a great variety; nine or ten kinds have been described by naturalists.

A fourth sort is of those which have many claws, yet they are not covered at the end with broad flat nails, but have them rather like talons, crooked and pointed; these are best distinguished by their teeth.

Some of these have many cutting teeth in each of their jaws; of these there is a greater sort, which either have a short round head, as the cat-kind, whereof there are seven sorts; and I hope the lion will not be offended if he be reckoned among them: or they have a long snout, as the dog-kind, whereof there are thirteen or fourteen sorts; and among these there are varieties of mongrels, and hebricious breeds: and there is also a lesser sort, which have a long and slender body, with short legs; these are the weasel-kind, and there are about eight sorts of them.

Others of these have only two remarkable teeth in each of their jaws; these are the hare-kind, which live mainly on plants and fruits; and there are about ten sorts of them. To these kinds of quadrupeds there must be added several that are anomalous. Some have a long snout, with feet which are divided into many claws, and are furnished with teeth; there are eight or nine sorts of these, whereof the hedge-hog is in the van. Others of these are destitute of teeth, and there

are two sorts of these. There are quadrupeds that are fliers too, as the bat kind, whereof there are different forms.

There is one very odd anomaly, which has but three claws on each of his four feet, and has a namesake, too often among those that go not upon four; a sloth we call it: he takes eight or nine minutes to move one of his feet three or four inches; and when he has grown fat and plump with eating all the leaves on a tree, he will be skin and bone before he reach another, which will be five or six days, though it may be very near the former.

There are also viviparous and sanguinous quadrupeds, breathing with lungs, but having only one ventricle in their hearts; to these we may add the tortoise, whereof there are many species, though they be rather oviparous. But then there are some oviparous quadrupeds, which have a long tail, horizontally stretched out; these are the lizard kind, and there be fourteen several sorts of them. The Frenchman who writes a Demonstration of the existence of God from the Knowledge of Nature, makes this remark: "All the animals owe their birth to a certain male and female of their species. All these different species are preserved much the same in all ages. We do not find that for three thousand years past any one has perished or ceased; neither do we find that any one multiplies to such an excess, as to be a nuisance or inconvenience to the rest."

And now since we are upon the four-footed, the remarkables in their legs and feet may be those which we may agreeably enough begin upon.

The prone posture of the body in quadrupeds

is not only most beneficial to themselves, but also most advantageous to man; they perform their own actions the better for that posture, and they serve man the better, both for carriage and for tillage. But then it is observable how exactly their legs are made conformable to that posture. It invites yet more observation, how admirably their legs and feet suit the exercises of every animal. The elephant, a creature of prodigious weight, has legs, as Pliny notes, like pillars rather than legs. The deer, and the hare, and other creatures of a singular swiftness, have their legs accordingly slender; but they have an incredible strength adapted to their swiftness. Some have their feet made only for walking and running, but some have them for swimming too. The toes on the feet of the otter are all conjoined with membranes, and in swimming, when the foot goes forward in the water, the toes are close; but when backward, they are spread out; by which they may forcibly strike the water, and are driven forward. The French academists are surprised at the extraordinary structure in the feet of the beaver: their hindmost feet, like those of a goose, are more proper to swim than to walk with: but their foremost are like hands rather than feet, and wonderously suit their occasions.

Some, as the moles, have their feet for walking and for digging. Some, as the bats, for walking and flying. In some the feet are more lax and weak, for the plainer lands; but others have them stiff, and less flexible; their joints hardly discernible, as the elks, and the goats, which are to traverse the ice, or to pass over the dangerous precipices of the mountains. In some the feet

are shod with tough and hard hoofs, either whole or cleft, as there is most occasion, in others they have only a callous skin. And here it is admirable to see how their toes are supplied, according to their several conveniences.

The structure of the bones in quadrupeds would be a large field for curiosity and admiration. Galen remarked a singular provision of nature for the strength of the lion, that his bones are much more solid than those of other animals.

Mr. Ray, inquiring how so many animals do to bear up against the extreme rigor of the cold, notes, that the extremities of their toes are fenced with hoofs, which in a good measure secure them: he adds, the main thing is, that the cold is its own antidote; for the air being fully charged and sated with nitrous, or some other sort of particles, (which are the great efficients of cold, and no less also the pabulum for fire) when it is inspired it causes a great accension in the blood (as we see the fire burns fiercely in such weather) as enables it to a vigorous resistance of the cold.

The defensive armour given to some creatures, with the skill to use it, how admirable! The hedge-hog, filled with sharp and strong prickles, has also a muscle given him on purpose, which enables him to contract himself into a globular figure, and so inclose himself in his thicket, that his rapacious enemies cannot lay hold on him. Olaus Borrichius is amazed at the wonderous fabric of that muscle. The armadilla, described by Marcgrave, is covered with a strong, hard, scaly crust or shell, of a bony substance, with four transverse commissures in the middle of the body, connected by tough membranes. By a peculiar

muscle he brings his tail to his head, and so gathers himself into a round ball, that there is nothing to be seen but his armature: had such a muscle been given to any animal covered with soft hair or fur, there might have been a pretence to fancy that this was accidental and undesigned; but seeing there is not one instance of this kind, Mr. Ray very justly says, it must be great stupidity to believe it, and impudence to assert it.

Let us pass to the head. The head of man is of one singular form. In the four-footed the form of the head is almost as various as the species, in some square and large, suitable to their food, motion, and abode; in others smaller, sharper, and more slender, still to suit those purposes. How surprisingly is the head and neck of swine adapted for its rooting in the earth. How the neck, nose, eyes and ears of the mole, adapted in the nicest manner to its subterraneous living. The strong snout of swine, such that he may sufficiently thrust it into the ground, where his living lies, without hurting his eyes; and of so sagacious a scent, that we employ him to hunt for us; and even his wallowing in the mire, is a wise contrivance for the suffocation of troublesome insects. The mole so shaped, that Dr. More makes this creature a notable ingredient in the composition of his Antidote against Atheism; even his want of a tail is a considerable contrivance for his advantage.

The brain of quadrupeds obliges us to employ ours in a particular contemplation of it; it is larger in us than in them, no doubt for the accommodation of a nobler guest, which we entertain in ours: but an exact anatomist of that part, the fa-

mous Dr. Willis, has led us more particularly to contemplate the situation of it. In man, to whom God has given a lofty countenance, with a capacity to think on heavenly things, the brain is placed above the cerebellum, and all the sensories; in brutes, whose brain is incapable of speculation, the cerebellum, whose business it is to minister to the actions and functions of the præcordia (the principal office in those creatures) is above the brain, and the eyes and ears are placed at least equal to it: moreover, in the head of man the base of the brain and cerebell is parallel to the horizon, by which means there is less danger of their jogging or slipping out of their place; but in brutes, whose head hangs down, the base of the skull makes a right angle with the horizon; and yet lest the cerebell should be unsteady, and the frequent concussions thereof should cause disorderly motions of the spirits about the præcordia, there is a sufficient provision made by the artifice of nature, by the dura meninx closely encompassing it; besides which, it has also in some a strong bony fence about it.

The carotid arteries passing through the skull of quadrupeds, and their branching into the rete mirabile, and some other such things, are particular accommodations to their circumstances, to prevent a too rapid incursion of blood into the brains of creatures that hang down so much.

At the great aperture of the shell in a tortoise, there is at the top a raised border, to grant a liberty to the neck and head, for the lifting of himself upwards; and this inflection of the neck is of great use to him, for without it he would be unable to turn himself when thrown upon his back. The

French academists looked upon the contrivance as a surprising one.

The varieties in the inner and outer ear of animals entertained Dr. Grew with observable curiosities. In an owl, that perches above, and hearkens after her prey below, it is produced further out above than it is below, that so the least sound from that quarter may be the more easily received; but in a fox that scouts underneath, it is for the same reason produced further out below. In a polecat, which hearkens directly forward, it is produced behind, for the taking of a forward sound; but a hare, which is very quick of hearing, and thinks of nothing but being pursued, has a bony tube, a natural otacoustick, so directed backward, as to receive the smallest and farthest sound that comes behind it; and in a horse, which receives the sound of the driver behind, the passage into the ear is like that of the hare.

It is remarkable that in quadrupeds the necks are commensurate to the legs; the equality in the length of their necks and their legs is most remarkably seen in beasts that feed constantly upon grass. But that which is yet more surprising, is, that in that sort of creatures which hold their heads down in an inclining posture for a considerable while together, which would be very painful to the muscles, on each side the ridge of the vertebres of the neck, nature hath placed a nervous ligament, very thick, elastic, strong, and void of sense, extending from the head to the middle vertebres of the back to assist them to support the head in that posture; it is by the vulgar called the whitleather.

Indeed this proportion is not kept in the ele-

phant, he has a short neck, the excessive weight of his head and his teeth to a long neck would have been insupportable. He is provided with a trunk, with which, as with a hand, he takes up his food, and his drink, and brings it to his mouth; a member so admirably contrived, that Mr. Derham has just occasion to say, it is a manifest instance of the Creator's workmanship.

On the mention of the elephant, we will introduce a particular curiosity relating to him; he has no epiglottis, because there is no danger of any thing falling into his lungs from eating or drinking, seeing there is in him no communication between the œsophagus and the passage into the lungs; the passage to the ventricle is through the tongue, a hole near the root of it is the beginning of the œsophagus, and the passage of the air into the mouth is quite stopped up; however, he is not sufficiently secured from small animals that may creep in and murder him; a mouse creeping up his proboscis, might get into his lungs, and so stifle him: to avoid this danger, when he sleeps he keeps his proboscis close to the ground, that nothing but air could get in. Mr. Ray celebrates this as a rare sagacity. The stomach of quadrupeds! how adapted to the various food intended for it! One kind of stomach in the carnivorous, another in the herbaceous. The peculiar contrivance on the stomach of the camel deserves our pause upon it; the words of the Parisian anatomists upon it, are, at the top of the second of the four ventricles there are several square holes, which were the orifices of about twenty cavities, made like sacks, placed between two membranes, which do compose the substance of this ventricle;

the view of these sacks made us think that they might well be the reservatories, where Pliny saith that camels a long time keep the water, which they drink in great abundance, to supply their wants in the dry deserts. In some of the quadrupeds the stomach is fitted for digestion upon bare mastication; but in others there is a whole set of stomachs, to digest with the help of rumination.

Dr. Grew observes, all carnivorous animals have the smallest ventricles, flesh going farthest; those that feed on fruits and roots have them of a middle size; sheep and oxen, which feed on grass, have the greatest; yet the horse, though graminivorous, has comparatively but a little one, because he is made for labour: the same is to be said of the hare, which is made for motion, for which the most easy respiration and the most free play of the diaphragm is requisite, and that could not be if the stomach was very large and cumbersome upon it.

There are domestic animals which look up to me for food, sometimes for the crumbs that fall from my table; I will consider myself as doing the part of a steward for the glorious God in feeding them; it shall be done with a holy delight, and with such an inference drawn from it as this: And will not the glorious God graciously and readily grant the mercy which I look up to Him to bestow upon me!

The food of the castor is generally of dry things, and such as are hard of digestion; and now there is a wonderful provision made in the stomach of that creature, by a digestive juice, lodged in curious little cells.

There is in the eye of brutes a nictating mem-

brane, to which the eye of man is a stranger; the Royal Academy at Paris have been very curious and punctual in the description of it: their opinion of it is, that this membrane serves to clean the cornea, and to hinder, that by drying it grow not less transparent. Man and the ape, which are the only animals wherein this membrane is not found, have not wanted this provision for the cleansing of their eyes, because they have hands, with which they may, by rubbing their eyelids, express the humidity contained in them, which they let out through the ductus lachrymalis; as is known by experience, when the light is darkened, or when the eyes are pained, or itching, these accidents do cease upon the rubbing of the eyes.

In the heart of quadrupeds there is an excellent provision for the living of those creatures.

The foramen ovale in some (that which in a fœtus makes the anastomosis, by the means whereof the blood goes from the cava into the aorta, without passing through the lungs) is an accession to the wonders.

This passage between the arteria venosa and the vena cava is kept open in amphibious quadrupeds; this maintains a degree of heat and motion in the blood, which may be sufficient for them while they are under water.

The epiglottis in such creatures is also larger and stiffer than it is in others, that so when they are feeding under water, the water may not break in upon their lungs.

I confess Mr. Cheselden is of the opinion, that it is not the foramen ovale, but the ostium venarum coronoriarum, which being very near it, may easily be mistaken for it, upon which the anato-

mists have made their curious remark; however the provision is admirable.

The heart in beasts is near the middle of the whole body, in man it is nearer the head; this Aristotle observes: but Mr. Lower, who has been a most curious anatomist of this part, gives us a reason for it; the trajection and the distribution of the blood wholly depending on the systole of the heart, and so either the heart must have been stronger in man, or the head would have wanted its due proportion of blood, if it had not been so near to the heart; whereas in beasts, whose heads hang down, the blood goes a plainer way, and often a steep one.

There are also peculiar nerves reaching to the heart of beasts, besides the sixth pair, as in man, a relief provided by nature, lest their prone heads might fail of imparting animal spirits copiously to it.

The cone of the pericardium in quadrupeds is loose from the diaphragm, whereas in man it is fastened to it; thus the motion of the midriff, in the necessary act of respiration, is assisted in the posture of both. Dr. Tyson's remark upon it is, this must be the effect of wisdom and design, and it is plain was intended in man to walk upright, and not upon all four, like the quadrupeds.

In the four footed there is not that communication between the head and the heart which there is in a man, especially by the branches of the intercostal pair of nerves, which are sent from the cervical plexus to the heart, and the præcordia, a thing which Mr. Derham cannot behold without calling it a prodigious care of nature; thus the head and heart of man have a more intimate

concern with each other, and a greater and quicker correspondence, than in other creatures: brutes are more simple machines; but in man, by the commerce of the cervical plexus, the conceptions of the brain presently affect the heart, and agitate its vessels, and the whole appendage of it, together with the diaphragm; whence the alteration in the motion of the blood, the pulse, and respiration; and when any thing affects or alters the heart, the impressions are not only retorted by the same duct of the nerves, but also the blood itself, with a changed course, flies to the brain, and there agitating the animal spirits with diverse impulses, produces various conceptions in the mind. This is Dr. Willis' observation; who adds, that the ancients therefore made the heart the seat of wisdom; and certainly the works of wisdom and virtue do very much depend upon the commerce which is between the heart and the brain.

The want of the intercostal commerce with the heart in brutes, is truly an admirable thing! Man, ponder upon this, and say, where is God my maker, who teaches us more than the beasts of the earth!

I cannot here forbear to introduce a good observation of a gentleman who writes Christian religious appeal, which he thus expresses; "That God should endow us with reason, and make us differ from the brutes, only that we may rule them, and not ourselves, and put a golden mattoc in our hands, only to dig dunghills; has not the least congruity with the decorum observed by Him in all His works, which are framed in weight, number, and order."

Galen gives us a notable relation of a kid, which he took alive out of the belly of the dam, and brought it up; the embryo presently fell to walking, as if he had heard, says Galen, that legs were given him for that purpose; then he smelt into all the things that were set in the room, and refusing them all, only supped up the milk: after two months the tender sprouts of shrubs and plants appeared, and then refusing the rest, he kept to those which are the peculiar food of goats. But that which to Galen appeared most admirable of all, was, that a while after it began to chew the cud; whereupon says he, all that saw cried out with admiration, being astonished at the natural faculties of animals. He complains thereupon that many neglect such works of nature, and admire none but unusual spectacles. Mr. Ray notes, one may fill a volume with comments on this pleasant story.

The sagacity of some quadrupeds, though so far short of man's, yet is a matter of astonishment to man; and man's will be short of theirs, if it see not the glorious God of nature operating in it.

Indeed there was humour enough in Rorarius, who upon hearing a learned man prefer such a wretch as Frederick Barberossa, before that great emperor Charles V. was thereby so provoked, that he wrote his two books to prove that beasts often have more use of reason than men.

It is enough that what of reason appears in the brutal tribes, is an immediate effect of the providence exerted by the all-wise Creator, and applied for the preservation of His creatures. O Lord, thou preservest not only man, but beast also!

The words of the excellent Sir Richard Blackmore, in his essay on the immortality of the soul, are worthy to be transcribed and pondered on this occasion. "I must acknowledge that I look upon the souls of brute creatures as immaterial, for I cannot conceive how an internal principle of sensitive perception and local motion can be framed of matter, though ever so subtile and refined, and modified with the most artful contrivance; yet they are plainly of a base and low nature, and destitute of those intellectual faculties and that free choice that should make them subjects of moral government, enable them to discern the obligation of laws, and the distinction of virtue and vice, and understand the notion of being an accountable creature, and receiving rewards and punishments. Whether the animal souls in a state of separation remain stupid and asleep, or whether they are dispersed through the creation, and employed to animate other beings, or return to one common element, whence they were at first derived, is unrevealed; but this is certain, the souls of brutes are not designed by the great Creator for such a life of pleasure and happiness, as that of human souls in a state of immortality and perfection, for the enjoyment of which they have no dispositions and capacities."

The opinion of Des Cartes, Gassendus, and Willis, and others, that the souls of brutes is material, and the whole animal a mere machine, is clogged with insuperable difficulties.

The excellent Mr. Ray, bespeaks a lower degree of reason for them, and his argument is brought from some of their actions, which, without allowing some argumentation in them, can

hardly be accounted for; he singles out the dog, running before his master, will stop at a divarication of the way, till he see which way his master will take. Again, when the dog has got a prey, which he fears his master will take from him, he runs away to hide it, and afterwards returns to it. Once more, if a dog be to leap upon a table which he sees too high for him to reach at once, let there be a stool or chair near it, he will first mount that, and so the table, yea, though the stool stand so that the creature takes not a direct leap towards the place finally intended; if he were a mere piece of clock-work, and this motion caused by the striking of a spring, there can be no reason imagined why the spring being set on work, should not carry the machine in a direct line towards the object that put it in motion, as well when it is on a high table, as when it is on a low.

They who have written of the fidelity and sagacity of dogs, have entertained us with stories full of wonders. The observers have thought themselves obliged sometimes to suspect that the dogs might have a spirit of Python in them. Camerarius in his horæ subcesivæ has collected surprising, but credible relations, of such as we may call reasonable dogs.

A well known king, who dealt much in them, at a famous act in one of the universities, very publicly determined it, that they could make syllogisms, and so it is no longer to be disputed. The authority is as great as that of Jacobus Micyllus, who wrote an elegy on a dog, which is thought a very elegant epigram.

There is a surprising thing related of the sea

tortoises, both Aristotle and Pliny have remarked it; that when tortoises have been a long time upon the water, during a calm, their shells will be so dried with the sun, that they are easily taken by the fishermen, because being become too light, they cannot plunge into the water nimbly enough. The French academists do not refer this easiness to be now taken, merely to the lightness of the creature's body, for he could easily let air enough out of the lungs to render his body heavier than the water, upon which he would sink immediately, but to a sagacity of the cautious animal, which is truly marvellous. The tortoise is always careful to keep himself in his equilibrium, and therefore he dares not let the air out of his lungs, to acquire a weight which would make him sink immediately; for he fears lest the wetting of his shell should render it so heavy, that being sunk to the bottom of the water, he might never afterwards have the power of re-ascending. What foresight here! what a degree of argumentation too!

The fox is often caught in tricks, which afford as pleasant stories as any in that old volume, the delectable history of reynard. His way to get rid of his fleas is notorious.

What notable architects are our beavers! they lay their logs, and build their dams, and form their chambers, with great art. A nation of Indians scarcely in any thing but their speech, exceed a nation of beavers.

What a notable, docible, tractable animal the horse! Read Solinus, and see what approaches the horse makes to reason! one would question which had most, Caligula or Incitatus. Dr. Grew admires him, as being swift and strong, above

most other animals, and yet strangely obedient; both comely and clean; he breeds no vermin of any sort; his breath, his foam, his excrements and sweat, all sweet and useful; fitted every way for service or pleasure, for the meanest or the greatest master. There are ancient examples of other horses besides Bucephalus and Lethargus, that have been honoured with stately funerals and sepulchres at their deaths, as well as their masters; yea, though the epitaph of Adrian be lost, his horse's is preserved to this day. The riders of horses, who in their lives will submit to no bridles, nor do any service for Him that made them, deserve at their deaths to pass away no better esteemed than their horses, but have a worse fate than they. The gentleman, who going home with his head full of the sickly fumes from the healths of the evening's debauch, could not compel his horse to drink a health which at the next brook he proposed to him, had so much reason left him (and a very little might serve) as to make that reflection, that the man in the saddle was the greater beast of the two.

How innumerable are the appearances of nature, which are above the powers of mechanism? It is religiously and most reasonably observed by Dr. Cheyne, that all these are so many undeniable proofs for the being of a God; there must be a power superior to those of mechanism, and this must lead us to Him, who alone does great and marvellous things.

How often have I heard this, and how plainly see it; this power belongeth to God! after all, do we see something in these, and other, and all creatures, that appear defective to us? A wise remark

made by the marquis of Pianezza shall be introduced upon it; his remarkable words are these:

"The limited perfections, and the seeming irregularities of the world, rather afford us occasion to acknowledge and glorify the providence of God, which not only declares, that all the creatures are too imperfect to deserve to be worshipped as deities, but also amidst their imperfections obliges them to confess, as it were with their own mouths, one infinitely perfect deity; a deity that would not have man fix on them as the objects of his love and admiration, but that from them he should pass on to the love and esteem of his only true God."

There is one very surprising thing, and without acknowledging a superintendency of a divine providence there can be no accounting for it. The mansuete creatures bring forth no more than one or two at a time, the beasts of prey bring forth as often, and seven, or nine, or eleven at a litter; and yet, what inexpressible multitudes of the mansuete have we to serve us! what vast herds of beeves! what vast flocks of sheep! whereas they that live upon prey appear in very little numbers. How rarely is a wolf met withal, though a price be set upon his head! what rarities are lions, and tigers, and ounces! to be caged in the tower for spectacles!

And then the liberty given us to butcher our useful creatures at our pleasure; it is observed by Mr. Robinson, that this will be found a kindness, rather than a cruelty to the creatures; if we kill them for our food, their despatch is quick, and much less painful, than that they should be torn to pieces by such cruel masters as the lion, and

the tiger, and bear, who would not give them time to die, but even eat their flesh from their bones alive; and if they should live to the tedious condition and melancholy of old age, it would, after many tortures, kill them, and leave their carcasses rotting, stinking, and useless upon the ground.

The short life of a beast, compared with the life of man, deserves some remark made upon it; this at least: man do not lead the life of a beast, if thou wouldst not be condemned and confined to the short life of a beast, nor come under the execution of that sentence, the days of the wicked shall be shortened. There is a way of living, by some called living apace; it is indeed not living at all, but rather dying apace; a beastly life ought to be a short one.

What useful instructions would the properties of the several animals yield to the Christian philosopher, would he be duly and wisely attentive to them! Franzius, and Simpson, and others, have cultivated this theme, usefully; it is capable of a much greater cultivation: Christian hearken to the voice of the many preachers thou hast about thee, lest thou mourn at the last, and say, I have not obeyed the voice of my teachers, nor inclined mine ear to them that instructed me!

The account which honest Leguat gives of the solitary bird, which he and his companions observed on the isle of Rodrigo, is as admirable as unquestionable; the bird has wings, but so small that it cannot fly with them, they serve to flutter with great noise when they call one another; they never lay but one egg, which is bigger than that of a goose; the male and female sit upon it in

their turns, and all the while they are hatching it, or bringing it to provide for itself, (which is divers months) they will not suffer any other bird of their own species to come within two hundred yards round the place: but this is very singular, the males will never drive away the approaching females, but call for their own females to do it; the female, and upon the approach of any other males, call their own males to chase them away. After these birds have raised their young one, and left it to itself, "we have often observed (says an ingenious traveller) that some days after the young one leaves the nest, a company of thirty or forty brings another young one to it, and the new-fledged bird, with his father and mother joining with the band, march to some by-place; we frequently followed them, and found that afterwards the old ones went each their way alone, or in couples, and left the two young ones together, which we called a marriage." This religious traveller gives all possible assurance for the truth of this relation, and adds, I could not forbear to entertain my mind with several reflections on this occasion. I sent mankind to learn of the beasts.

It is an observation made by one of the most refined philosophers by whom our age has been illuminated; "Most creatures have some quality, whereby they admonish us of what is best. Of neatness, all birds which love to be pruning themselves; and cats, which commonly cover their excrements, and wipe their mouths after dinner. Foul water will breed the pip in hens, and filth, lice and crabs in kine; and all creatures, even swine themselves, which love dirt, yet thrive best when kept clean. Of forecast, the

sitta and the ant, which lay up nuts and other seeds in their granaries, that serve them in the winter. Of modesty, the elephants, the dromedaries, and the deer, which always conceal their venereal acts. Of mature marriage, all animals which beget their best breed at their full growth. Of conjugal chastity, the doves and partridges, which keep to one husband and wife. Of conjugal love, the rook, the male helping the female to make her nest, feeding her while she sits, and often sitting in his turn. Of maternal love, the domestic hen, gentle by nature, and unarmed, yet, in defence of her chickens, bold and fierce; and the tiger herself, the fiercest of beasts, yet is infinitely fond of her whelps."

The same excellent Fellow of the Royal Society carries on his observation: "The most odious or noxious things serve for food, physic, manufacture, or other good use; neither are they of less use to amend our minds, by teaching us care, and diligence, and more wit: and so much the more, the worse the things are, we see and should avoid. Weasels, kites, and other mischievous animals, induce us to watchfulness; thistles and moles to good husbandry; lice oblige us to cleanliness in our bodies, spiders in our houses, and the moth in our clothes: the deformity and filthiness of swine make them the beauty-spot of the animal creation, and the emblem of all vice; and the obscenity of dogs shews how much more beastly it is in men: the fox teaches us to beware of the thief, and vipers and scorpions those more noxious creatures, which carry their venom in their tongues or their tails."

I will prosecute this observation of my brother,

with observing, that no little part of the homage we owe to the glorious Creator of all these things is to learn those virtues, and those decent and honest things, whereof, if the faculties of our minds be awake, we shall easily perceive His creatures to be the monitors.

The kindness of the brutes to those of their own kind, rebukes the unbrotherly carriage too often found in mankind; and adds a variety of admonitions, which, my reader, thou art not unable to discover by thy own ingenuity.

"But of all the tribes that graze in the field, there is none that I would more choose for an emblem than the sheep; the clean, patient, innocent creature, which has nothing belonging to it but what is of a celebrated usefulness. O thou most honourable creature, what a dignity has the Son of God himself put upon thee!"

"I see so much of God in the circumstances of the brutal tribes, as obliges me to look upwards in a way too high for them. At the same time, though I would by no means fall into Pythagorean and Mahometan superstitions, yet I would abhor to treat any of the brutes with barbarous cruelty; cruelly to delight in their misery, or to be unmerciful to them, is an offence to God, and what a righteous man would not be guilty of; unknown punishments may be reserved for it."

"Great God, if I do not acknowledge thee, I am condemned by the ox, which knows his owner, and by the ass, which knows his master's crib!" Luther seeing the cattle go in the fields, used this expression; Behold, there go our preachers, our milk-bearers, and wool-bearers, which daily preach to us faith towards God, that we trust in Him as

our loving Father, who will maintain and nourish us.

It is very certain our dominion over the creatures is very much impaired by our fall from God. Those creatures do now either fly from us, or fly at us, which, if we had been faithful to our God, would not have done so.

I conclude with an observation of Dr. Grew's; "As the essence of every thing, and its relation, in being fitted, beyond any emendation, for its actions and uses, evidently proceeds from a mind of the highest understanding, so the nature of these actions and uses, in as much as they are not any way destructive or troublesome; no, but each thing tends apart, and all conspire together to conserve, cherish, and gratify: this is an evidence of their proceeding from the greatest goodness. There are many who are very cunning and subtle in the invention of evil, and engines have been fitted, with much contrivance, for tormenting men; how easy had it been for the Creator of the universe to have stocked it with creatures that should never have moved so much as one limb without pain, or have had the least sensation without a mixture of horrible torment, or have entertained the least imagination, unattended by horror? But behold, our good God has ordered it, that whatever is natural is delightful, and has a tendency to good; He has employed his transcendent wisdom and power, that He might make way for his benignity."

Great God, thou art good, and thou dost good; O teach me thy statutes!

ESSAY XXXII. *Of* MAN.

AND now let the lord of this lower world be introduced, MAN, who is to do the part of a priest for the rest of creation, and offer up to God the praises which are due from all.

It was most reasonably done of thee, father Austin, to tax the folly of them who admired the wonders in the other parts of the creation abroad, but see nothing in themselves wonderful. It is not without meaning that mankind are in the gospel called, every creature; he that beholds man, may therein behold what is wonderful in every creature.

"Nature doth not lead thee towards God by a far-fetched and winding compass, but in a short and straight line. The sun waits upon the rain, the rain upon the grass, the grass serves the cattle, the cattle serve thee, and if thou serve God, then thou makest good the highest link in that golden chain, whereby heaven is joined to earth; then thou standest where thou oughtest to stand, in the uppermost round of the divine ladder, next to the Most High! then thou approvest thyself to be indeed what thou wert designed by God to be, the high priest and orator of the universe; because thou alone, amongst all the creatures here below, art endued with understanding to know him, and speech to express thy knowledge of him, in thy praises and prayers to him."

The body of man, being most obvious to our view, is that with which we will begin; a machine of a most astonishing workmanship and contrivance. My God, I will praise thee, for I am strangely and wonderfully made!

"But is it possible for me to c[illegible]othing deficient, as any other than a temple of God[illegible]se for every instructs us that the most exquisite and[illegible]well spare, figure for a temple will be found in a com[illegible]ceed of to a human body; indeed a human body o[illegible]rel for ever to be beheld and employed, as designed for a holy temple; for me to apply any part of such a body to any action forbidden by God, would be a very criminal prostitution."

"By using my body for the service of God, and by praising the glorious One, who has formed every part of my body, and clothed me with skin and flesh, and fenced me with bones and sinews, I desire to assure my share in a happy resurrection of this body from the grave, into which it is falling: for though a man die he is to live again; an appointed time will come, when thou, O my God, wilt call, and I shall answer thee, and thou wilt have a desire to see the work of thine hands revived and restored."

The erect posture of man, how commodious for a rational creature, who must have dominion over those who are not so, and must invent and practise things useful and curious. By this posture man has the use of his hands; and his eyes, which as they have the glorious hemisphere of the heavens above him, so they have the horizon of three miles on a perfect globe about them, when they are six feet high, and by the refractions of the atmosphere they have more. His head is also sustained, which is heavy, and how painful to be carried in another posture.

The provision made for this posture is very surprising. What ligaments, especially that of the pericardium to the diaphragm, which is pecu-

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AND [illegible]rkably the vertebræ of the
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gravity wh[illegible]ught to be; yea, all the parts of the body so disposed as to poise it nicely! with a prodigious variety of muscles placed through the body for the service. Borelli observes, "It is worthy of admiration, that in so great a variety of motions nature's law of equilibration should always be observed; so that if it be transgressed or neglected, the body necessarily and immediately tumbles down." Every thing does conspire to assure us, that the Maker of man intended him for such a posture.

In the most indigent condition wherein man is born into the world, the plentiful provisions which he finds made by a gracious and merciful God for him in the world, invite man to return to God, and to taste his love, in all the creatures that accommodate him, and rely upon his care for ever, for for the supply of all his wants.

A comparison between the macrocosm and the microcosm would afford a very edifying and acceptable entertainment to a contemplative mind. Indeed he who speaks to man, speaks to every creature; and man is therefore the more concerned, as well as capable to hear every creature speaking to him.

It is what calls for a deep consideration with us,

that in the body of man there is nothing deficient, nothing superfluous, an end and use for every thing. There is no part that we can well spare, nor any that can say to the rest, I have no need of you. The belly and the members cannot quarrel with one another. Even the paps in men, besides their adorning the breast, and their defending the heart, sometimes contain milk, as in a Danish family, mentioned by Bartholinus. A man mentioned by Beccone, upon the death of his wife, suckled the infant himself. He concludes, that since, according to Malpighius and others, the paps of men have the same vessels with those of women, it is intended that, if need requires, the young should be suckled at them, who, upon a little pulling, soon fetch milk into them.

Mr. Ray remarks, that if we consider no more than the very nails at our fingers ends, we must be very sottish if we can conceive that any other than an infinitely good and wise God was our author and former.

No sign of chance in the whole structure of our body. It is remarkable, in bodies of different animals there is an agreement of the parts, as far as their occasions and offices agree; but a difference of those where there is a difference of these. Dr. Dowglass will tell you what muscles are in a man that are not in a dog, what in a dog that are not in a man. The matter, texture, figure and strength, with the necessary accoutrements of every part, how amazingly commodious!

In the body of man the lodgment of the parts is as admirable as the parts themselves. Where could the eye, ear, and tongue be so commodiously placed as in the upper apartments assigned for

them? Four of the five senses, how commodiously lodged, near the brain, the common sensory, and a place well guarded; Galen celebrated this wonderously agreeable situation. And how could the fifth sense, that of the touch, be more agreeably lodged, than with a dispersion into all parts of the body! where should the hands, the feet, the legs be, but just where they are! where the heart, the sol microcosmi, which is to labour about the whole mass of blood, but in the centre of the body? Where can the viscera discharge their offices better, than in the place assigned to them? Where could the bones and the muscles be better disposed of? And what better covering were it possible for the whole body to have, than the skin; whereof the microscopical views given by Cowper in his anatomy, must surprise us.

What can be more ornamental, than that those members which are pairs, do stand by one another in an equal altitude.

The provision made in the body of man to ward off evils, is very admirable. The secretions made by the glands, whereof Cockburn, Keil, Moreland, and others, give us accounts, are such as cannot be considered without some amazement. How many parts of the body stand ready to do what belongs to faithful sentinels. The principal and more essential instruments of life and sense, how well are they barricadoed? Of how many parts are we supplied with pairs, to make up a defect which may happen in any of them? The pairs of nerves, and the ramifications of the veins and arteries in the fleshy parts, what cases of disaster are answered in them? Mr. Derham here justly adores the infinite Contriver. Dr. Sloane

admires the contrivance of our blood, which on some occasions, as soon as any thing destructive to the constitution comes into it, immediately by an intestine commotion endeavours to thrust it forth, and so it is not only freed from the new guest, but sometimes what likewise might long have lain lurking there.

What emunctories has the body, and what surprising passages, to carry off mischiefs, which we foolishly bring upon ourselves! and how astonishing the methods and efforts of nature to set all things to rights. Valsalva discovered passages into the region of the ear-drum, which are of mighty use to discharge morbific matter from the head. Hippocrates in his book de Alimentis makes his remarks upon the sagacity of nature, to find out passages for the discharging of things offensive to the body. Modern stories of what nature has done for this, occurring in the German ephemerides, and elsewhere, would scarce be credible, were not the fidelity of the relators irreproachable. Dr. Grew bestows his just remarks upon it, that in most wounds, if kept clean and from the air, the flesh will glue together with a native balm of its own; and that broken bones are cemented with a callus, which they themselves help to make: yea, diseases themselves are not useless, for the blood in a fever, if well governed, like wine upon the fret, will discharge itself of all heterogeneous mixtures. But the philosopher last quoted observes, nothing can be more admirable than the many ways nature hath provided for preventing or curing of fevers. Mr. Boyle and others have entertained us with surprising relations, how the senses of seeing and hearing have

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The variety of the parts whereof the body is composed, cannot but compel our admiring souls to acknowledge our glorious Maker.

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The scarf-skin examined with a microscope, appears made up of lays of exceeding small scales, which cover one another more or less, according to the different thickness of the scarf-skin in the several parts of the body; but in the lips they only in a manner touch one another. Leuenhoeck reckons that in one cuticular scale there may be five hundred excretory channels, and that one grain of sand will cover two hundred and fifty scales; wherefore one grain of sand will cover one hundred and twenty five thousand orifices, through which we are daily perspiring. What a prodigious number of glands must there now be on the surface of the whole body! into every one of these glands there enters an artery, a vein, and a nerve. How many organs now in all the body! look upon thy skin, O man, and say, great God, how wonderously hast thou clothed me!

Daily perspiring, I said—The sum of all the particles that are strained through the cuticular glands, is reckoned by Sanctorius to amount to about fifty ounces in a day; so that supposing a

man's body to weigh one hundred and sixty pounds, in fifty one days, a quantity equal to the whole body is perspired. The medicina statica will multiply the calls to us to glorify the God who so upholds our souls in life.

But when the multitude of intentions which our Creator has in the formation of our several parts, and the qualifications they require to fit them for their various uses, this also calls for our wonders. Dr. Wilkins takes notice, that according to Galen there are in a human body above six hundred several muscles, and there are no less than ten several intentions to be observed in each of these; about the muscles alone there are at least six thousand several ends or aims to be attended to. They reckon the bones to be two hundred and eighty four, the distinct intentions of each of these are no fewer than forty; the whole number of scopes for the bones arise to a hundred thousand: thus it is in proportion to all the other parts, the skin, ligaments, vessels, glandules, humours, but more peculiarly with the several members of the body, which do in regard of the multitude of intentions or qualifications required to them, very much exceed the homogeneous parts; a failing in any one of these would cause an irregularity in the body, and in many of them, as the doctor notes, it would be such as would be very notorious. My friend, contemplate the figures of Spigelius, Bidloe, and Lyserus, if thou canst without astonishment! who can behold a machine composed of so many parts, to the right form, order, and motion whereof there are such an infinite number of intentions required, without crying out, who can be comapred to the Lord!

The variety of offices which sometimes one part performs, will here come into consideration. Thus the tongue, it serves for tasting, and also for the mastication and the deglutition of our food; and then for the formation of our words in speaking, the use of it is admirable! The diaphragm, with the muscles of the abdomen, are of use, not only in respiration, but also for the compression of the intestines, that the chyle may be forced into the lacteal veins, and out of them into the thoracick channel; and no doubt the comminution of the meat in the stomach is likewise hereby assisted.

The muscular contraction of the heart, in the pulse of it, serves not only for the circulation of the blood, but also for the more perfect mixture of it, by which it is preserved in its due crasis and fluidity, and it incorporates the chyle and other juices it receives with it.

Even pain itself, however afflictive it be, yet is of use to us; it quickens us to seek for help, and makes us careful to avoid what may be for our hurt.

The mention of pain leads one to think on sleep; sleep, a thing so necessary to repair the great expense of spirits we make in the day-time, through the constant exercise of our senses and motion of our muscles. It is a little surprising, that though we lie long on one side, we have no sense of pain during our sleep, nor when we awake. One would think the whole weight of the body pressing the side on which we lie, should be very burdensome and uneasy, and create a grievous pain to us; and if we lie long awake we really find it so. Mr. Ray supposes that our ease in this case may be owing to an inflation of the

muscles, whereby they become soft, and yet renitent, like so many pillows, dissipating the force of the pressure, and so the feeling of the pain. Hence when we rest in our clothes we loose our garters, our buckles, and other ligatures, to give the spirits a free passage, else these parts will be pained, which when we are awake are not so. The reason of this freedom from pain during and after a long sleep on one side, is by Dr. Lyster and by Dr. Jones, attributed to the relaxation of the nerves and muscles in the time of sleep; or pain while we lie awake, is owing to the tension of them. O merciful God, thou makest my bed for me!

Let more particular parts of our body come into consideration with us; it is impossible for them to do so without coming into admiration too!

The head ought certainly to be the first considered. The head, because it must contain a large brain, is made of a most capacious figure, as near as may be to a spherical.

What an infinite number of glands in the cortical part, and of beginning nerves in the medullar part; an hundred whereof exceed not one single hair.

Upon the head grows the hair, which is of great use, not only to quench the stroke of a blow at the skull, but also to cherish the brain; it serves also to disburden the brain of a superfluous moisture, wherewith it abounds. Marchetti finds that baldness comes from the dryness of the brain, and the shrinking of it from the skull; he found an empty space between the brain and the skull in the bald. The hair is likewise a graceful ornament, else, as Mr. Ray observes, the present age would not bestow so much money upon periwigs.

How commodiously are the nerves, wherewith four of the senses are served, as well as all the superior parts, all sent out the shortest and safest ways, through proper holes in the head. And those that serve the inferior; carried down in a bony channel. And it is very remarkable, that the veins do not pass out at the same holes the arteries enter; for if they did, then upon any violent motion of the blood, or any greater quantity thereof than ordinary, lodged in the arteries, their dilatation and pulsation would compress the veins against the bony sides of their passage, and so occasion a stagnation and extravasation of the blood in the brain, to the destruction of the whole machine, which by these different entries and exits of these vessels is prevented.

The brain—the cortical parts of which serve to make the animal spirits; that is, to separate them from the blood: the medullary parts to receive them, and convey them from thence into the nerves.

The inner meninx, by its constriction, upon occasion, causes a more vigorous efflux of the spirits, and thereby the better irradition of the organs of motion and sense. By the frequent repetition of this constriction all the day, being tired, as all other muscles are by continual action, it is anon relaxed, or suspended from action. Hereupon, the efflux of the spirits into the said organs, being made more slowly, we fall asleep.

A great philosopher observes and affirms, that the clearness of our fancy depends on the regular structure of the brain; by which it is fitted for the receiving and compounding of all impressions with the more regularity. In fools the brain is

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One instance is by Mr. Derham singled out; there is one conjugation of the nerves, which is branched into the ball, and the muscles, and the glands of the eye; to the ear, to the jaws, and the gums, and the teeth; to the muscles of the lips, to the tonsils, the palate, the tongue, and the parts of the mouth; to the præcordia too; and lastly, to the muscles of the face, and very particularly those of the cheeks. Hence is is that a gustable thing, seen or smelt, excites the appetite, and affects the glands and parts of the mouth. A shameful thing seen or heard affects the cheeks. If the fancy be pleased, the præcordia are affected, and the muscles of the mouth and face are put into the motions of laughter. When sadness is caused, it exerts itself upon the præcordia, and the glands of the eyes emit their tears; wherein also, as was long since noted, Fletus ærumnas levat, and the muscles of the face put on a sorrowful aspect. Hence also the torvous look, produced by anger and hatred; and a gay countenance accompanies love, hope, and joy. Finally, hence it is that, as Pliny notes, the face in man alone is the index of all the passions.

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muscles, whereby they become soft, and yet renitent, like so many pillows, dissipating the force of the pressure, and so the feeling of the pain. Hence when we rest in our clothes we loose our garters, our buckles, and other ligatures, to give the spirits a free passage, else these parts will be pained, which when we are awake are not so. The reason of this freedom from pain during and after a long sleep on one side, is by Dr. Lyster and by Dr. Jones, attributed to the relaxation of the nerves and muscles in the time of sleep; or pain while we lie awake, is owing to the tension of them. O merciful God, thou makest my bed for me!

Let more particular parts of our body come into consideration with us; it is impossible for them to do so without coming into admiration too!

The head ought certainly to be the first considered. The head, because it must contain a large brain, is made of a most capacious figure, as near as may be to a spherical.

What an infinite number of glands in the cortical part, and of beginning nerves in the medullar part; an hundred whereof exceed not one single hair.

Upon the head grows the hair, which is of great use, not only to quench the stroke of a blow at the skull, but also to cherish the brain; it serves also to disburden the brain of a superfluous moisture, wherewith it abounds. Marchetti finds that baldness comes from the dryness of the brain, and the shrinking of it from the skull; he found an empty space between the brain and the skull in the bald. The hair is likewise a graceful ornament, else, as Mr. Ray observes, the present age would not bestow so much money upon periwigs.

How commodiously are the nerves, wherewith four of the senses are served, as well as all the superior parts, all sent out the shortest and safest ways, through proper holes in the head. And those that serve the inferior; carried down in a bony channel. And it is very remarkable, that the veins do not pass out at the same holes the arteries enter; for if they did, then upon any violent motion of the blood, or any greater quantity thereof than ordinary, lodged in the arteries, their dilatation and pulsation would compress the veins against the bony sides of their passage, and so occasion a stagnation and extravasation of the blood in the brain, to the destruction of the whole machine, which by these different entries and exits of these vessels is prevented.

The brain—the cortical parts of which serve to make the animal spirits; that is, to separate them from the blood: the medullary parts to receive them, and convey them from thence into the nerves.

The inner meninx, by its constriction, upon occasion, causes a more vigorous efflux of the spirits, and thereby the better irradition of the organs of motion and sense. By the frequent repetition of this constriction all the day, being tired, as all other muscles are by continual action, it is anon relaxed, or suspended from action. Hereupon, the efflux of the spirits into the said organs, being made more slowly, we fall asleep.

A great philosopher observes and affirms, that the clearness of our fancy depends on the regular structure of the brain; by which it is fitted for the receiving and compounding of all impressions *with the more* regularity. In fools the brain is

them? Four of the five senses, how commodiously lodged, near the brain, the common sensory, and a place well guarded; Galen celebrated this wonderously agreeable situation. And how could the fifth sense, that of the touch, be more agreeably lodged, than with a dispersion into all parts of the body! where should the hands, the feet, the legs be, but just where they are! where the heart, the sol microcosmi, which is to labour about the whole mass of blood, but in the centre of the body? Where can the viscera discharge their offices better, than in the place assigned to them? Where could the bones and the muscles be better disposed of? And what better covering were it possible for the whole body to have, than the skin; whereof the microscopical views given by Cowper in his anatomy, must surprise us.

What can be more ornamental, than that those members which are pairs, do stand by one another in an equal altitude.

The provision made in the body of man to ward off evils, is very admirable. The secretions made by the glands, whereof Cockburn, Keil, Moreland, and others, give us accounts, are such as cannot be considered without some amazement. How many parts of the body stand ready to do what belongs to faithful sentinels. The principal and more essential instruments of life and sense, how well are they barricadoed? Of how many parts are we supplied with pairs, to make up a defect which may happen in any of them? The pairs of nerves, and the ramifications of the veins and arteries in the fleshy parts, what cases of disaster are answered in them? Mr. Derham here justly adores the infinite Contriver. Dr. Sloane

The spherical form of the eye, how commodious, to lodge the humours, and also to take in the objects, and likewise to befriend the motions! The parts of the eye being made convex, especially the crystaline, which is of a lenticular figure, convex on both sides; by the refractions there made, there is a direction of many rays coming from one point in the object, viz. as many as the pupil can receive, to one point answerable in the bottom of the eye, without which the sense would be obscure and confused. The difference between a picture that is received on a white paper in a dark room, through an open or empty hole, and the same received through a hole furnished with an exactly polished lenticular crystal, is brought by Mr. Ray to illustrate this.

The membranes and humours of the eye are all purely transparent and pellucid; thus none of the rays let in are suffocated before they reach the bottom of the eye, nor are they sophisticated with the tincture of any colour, by which that colour might be refunded on the object, and the soul deceived.

The uveous coat or iris of the eye has a musculous power, and can contract or dilate the pupil; the former is to preserve the eye from injury, by too lucid an object that may be too near it; the latter is to apprehend a remoter object, or one placed in a fainter light. There are some animals which can so close the pupil as to admit of, one may say, one single ray of light, and by throwing all open again they can take in the faintest rays; it is an incomparable provision for them who watch for their prey in the night. These have also another astonishing provision for their

business, which is a radiation of the eyes, from the shining of the retina about the optic nerve. Man has not this provision, because he has no occasion for it; and yet there have been instances of some whose iris has had the faculty so to dart out rays of light, that they could see in the dark.

The uveous coat and the inside of the choroides are wonderfully blackened; this is, that the rays may be suppressed there, and not so reflected backwards as to confound the sight; if any be reflected by the retiform coat, they are soon choaked in the black inside of the uvea; were they to and fro reflected, there could be no distinct vision; as the light admitted into a dark room would obliterate the species, which before were seen upon white paper, by the light let in through an orifice in the wall.

Dr. Grew makes a just exclamation: What more wonderful than to see two humours of equal use to true vision, bred so near together as to be contained within one common coat, and yet one of them as clear as crystal, the other as black as ink!

Since the rays from an object nearer to us, or farther from us, do not meet just in the same distance behind the crystaline humour, therefore the ciliary processes, or the ligaments observed in the inside of the selerotick tunicles of the eye, serve instead of a muscle, by their contraction, to alter the figure of the eye, and make it broader; and consequently draw the retina nearer to the crystaline humour, and by the relaxation thereof suffer it to return to its natural distance according to the exigency of the object in respect of distance more or less. Dr. Grew ascribes to the ligamentum ciliare a power of making the crystaline more

convex, as well as of moving it either to or from the retina; and indeed by the laws of optics there must be something of this necessary to distinct vision.

The crystaline humour, when dried, appears manifestly to be made up of many very thin spherical scales, lying one upon another; Leuenhoeck reckons there may be two thousand of them in one crystaline, from the outermost to the centre: every one of these wonderful scales are made up of one single fibre, or the finest thread imaginable, wound in a stupendous manner, this way and that way, so as to run several courses, and meet in as many centres, and yet not in any one place to interfere to cross one another. Some ingenious men have questioned this, but Mr. Derham says, it is what I myself have seen, and can shew to any body with the help of a good microscope.

Peter Herigon has observed a remarkable thing about the insertion of the optic nerve into the bulb of the eye. The situation of it is not just behind the eye, but on one side, lest that part of the image which falls upon the hole of the optic nerve should want its picture. But Mr. Ray will rather have the reason to be, because if the optic axis fall upon such a centre, as it would were the nerve seated just behind the eye, this great inconvenience would follow, that the middle point of every object we viewed would be invisible, or there would a dark spot appear in the midst of it. Behold, a situation of a nerve, which any one would at first have thought inconvenient, now evidently found to be assigned by a most admirable Wisdom.

And then, what a wise contrivance, particularly about the motion of the eye, uniting into one that

only divers countries pronounce in ways peculiar to themselves, but in the same country how many dialects? Britain as well as Greece exemplifies this variety; thus Gileadites can discover Ephraimites. A Lapide tells us how the Flemings discover a Frenchman; and Fuller, what way they took in England long since to discover a Dutchman: yea, some have demonstrated that voices do distinguish individuals as much as faces, and in some cases more; for this way the discovery is made in the dark, and by the blind also.

Thirdly, Dr. Cockburn shall supply us with one dissimilitude more: "To no other cause than the wise providence of God can be referred the no less strange variety of hand writings. Common experience shews, that though hundreds and thousands were taught by one master, and one and the same form of writing, yet they all write differently; there is something peculiar in every one's writing, which distinguishes it; some indeed can counterfeit another's character and subscription, but the instances are rare, nor is it done without pains and trouble: nay, the most expert and skilful cannot write so exactly like, that it cannot be known whether it be genuine or counterfeit; and if the providence of God did not so order it, what cheats and forgeries too would be daily committed, which would run all into confusion? The diversity of hand writing is of very great use to the peace of the world; and what is so very useful is not the effect of any human concert; men did not of themselves agree to it, they are only carried to it by the secret providence of God." My God, let me never do any thing that may be to the damage of that which thou proclaimest thyself

be wounded or pricked, and this fluid humour let out, there is therefore a provision made, speedily to repair it, by the help of certain water pipes, or lymphaducts, inserted into the bulb of the eye, proceeding from glandules designed by nature to separate this water from the blood for that use. Antonius Nuck found, that if the eye of an animal be pricked, and the aqueous humour squeezed out, in the space of ten hours the humour and sight would be restored to the eye, at least if the creature be kept in the dark. Verzascha gives divers examples, both ancient and modern, of sight strangely recovered, by the reparation of the aqueous humour, after it had been let out at very dangerous wounds.

It is remarkable, that the horny coat of the eye does not lie in the same superficies with the white of the eye; but it rises up, as it were on a hilloc, above its convexity, and is of an hyperbolical or parabolical figure. Though the eye seems to be perfectly round, in reality it is not so; but the iris thereof is protuberant above the white: and the reason is, because if the cornea tunica, or crystaline humour, had been concentrical to the sclerodes, the eye could not have admitted a whole hemisphere at one view.

Dr. More remarks, that the eye being thus perfect, the reason of man would easily have rested here, and admired the contrivance. Being able to move himself every way, he might have thought himself every way sufficiently provided for. But behold! an addition to this perfection! there are muscles also added to the eyes! for we have occasion, particularly in reading to move our *eyes, without* moving our head. The organ is

man's body to weigh one hundred and sixty pounds, in fifty one days, a quantity equal to the whole body is perspired. The medicina statica will multiply the calls to us to glorify the God who so upholds our souls in life.

But when the multitude of intentions which our Creator has in the formation of our several parts, and the qualifications they require to fit them for their various uses, this also calls for our wonders. Dr. Wilkins takes notice, that according to Galen there are in a human body above six hundred several muscles, and there are no less than ten several intentions to be observed in each of these; about the muscles alone there are at least six thousand several ends or aims to be attended to. They reckon the bones to be two hundred and eighty four, the distinct intentions of each of these are no fewer than forty; the whole number of scopes for the bones arise to a hundred thousand: thus it is in proportion to all the other parts, the skin, ligaments, vessels, glandules, humours, but more peculiarly with the several members of the body, which do in regard of the multitude of intentions or qualifications required to them, very much exceed the homogeneous parts; a failing in any one of these would cause an irregularity in the body, and in many of them, as the doctor notes, it would be such as would be very notorious. My friend, contemplate the figures of Spigelius, Bidloe, and Lyserus, if thou canst without astonishment! who can behold a machine composed of so many parts, to the right form, order, and motion whereof there are such an infinite number of intentions required, without crying out, who can be comapred to the Lord!

The variety of offices which sometimes one part performs, will here come into consideration. Thus the tongue, it serves for tasting, and also for the mastication and the deglutition of our food; and then for the formation of our words in speaking, the use of it is admirable! The diaphragm, with the muscles of the abdomen, are of use, not only in respiration, but also for the compression of the intestines, that the chyle may be forced into the lacteal veins, and out of them into the thoracick channel; and no doubt the comminution of the meat in the stomach is likewise hereby assisted.

The muscular contraction of the heart, in the pulse of it, serves not only for the circulation of the blood, but also for the more perfect mixture of it, by which it is preserved in its due crasis and fluidity, and it incorporates the chyle and other juices it receives with it.

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depraved as not to acknowledge the bounty and wisdom of the Author of his nature, in the ravishing and astonishing structure of this noble organ! "Good God! how unreasonable am I, if the eyes made by Him should not be ever to the Lord! an envious eye is an abused one; a haughty eye is a distorted one; an unchaste eye, how ignominiously misapplied! it has dirt thrown into it. Gracious God, let not my eyes be port-holes of wickedness. Let no death get into my soul by those windows. A pitiful eye a bountiful eye, and the eye on the book that will feed it well, how much to be wished for! and an eye upon a Christ at his table, evidently set forth as crucified before it."

The ear is what falls next under our consideration; double, not only to provide against the loss of one, but also for the more commodious hearing.

It is astonishing to see the sagacity of some deaf persons, who come to understand things that are spoken, only by seeing the motion of the lips in the speaker; but the instances of this are so rare, that they abate nothing of our obligations to our glorious Maker for bestowing the noble sense of hearing upon us.

The situation of the ear is where it may give the most speedy information, and where it will occasion and also encounter the least annoyance. The outward ear is most nicely adjusted to the peculiar circumstances of every animal. Dr. Grew celebrates the marvellous varieties in the ears of several animals for the reception of sound, according to their several exigencies. And Mr. Derham challenges our confession of a notable *prospect* of the handy work of God even in so in-

considerable a part as this. In man the form of it is of all the most agreeable to the erect posture of his body.

What a surprising spectacle the helix, which in its tortuous cavities collects the sonorous undulations, and gives them a gentle circulation, with some refraction, and conveys them to the concha, that large and round cell at the entrance of the ear! then to bridle the evagation of the sound when arrived thus far, but at the same time avoid any confusion thereof by repercussions, what a curious provision is there made by those little protuberances called the tragus and the antitragus of the outward ear, softer than the helix, and blunting the sound without repelling it! Monsieur Dionis observes, they that have this ear cut off have but a confused way of hearing.

That the substance of the outward ear should be cartilaginous, is an admirable contrivance of the most wise Creator. Dr. Gibson observes, if it had been bone, it would have been troublesome, and might by many accidents have been broken off; if it had been flesh, it would have been subject to contusion, yea, we may add, it would not then have remained so well expanded, nor have so kindly received sounds, but have absorbed them, and retarded them; whereas now the sounds have their agreeable volutations, as in well built arches, and the whispering places, whereof the world has had many famous ones.

How artfully tunnelled the auditory passage! but then because the passage must be always open, therefore to prevent the invasion of noxious things, which love to retreat into every little hole, *behold, the* passage secured with a bitter and nau-

seous excrement, afforded from glands appointed for that purpose! where the meatus auditorius is long enough to afford harbour to any insects, there this ear-wax is constantly to be found; but birds, whose eyes are covered with feathers, and where the tympanum lies but a little way within the skull, have none of it. Schelhammer confutes the old anatomists, who make this ear-wax an excrement of the brain, and justly says, there is nothing more absurd. Dr. Drake has given us a handsome cut of the glandulæ ceruminosæ. Pliny ascribes a great medical virtue to the ear-wax, as curing the bites of men, and of scorpions and serpents. And Mr. Derham asserts he had found it a good balsam in his own experience.

The notion of an innate air in the ear, is by Schelhammer found but a fancy; the passage into the inner ear from the throat confutes it: but in this passage there is a wise provision, that no air might pass in thither but what shall be changed and warmed, and so rendered harmless.

The passage from the ear to the palate is accurately described by Valsalva; this is to give way to the inner air upon every motion of the membrana tympani, the malleus, the incus, and the stapes; and if this be shut up, deafness ensues.

And then the os petrosum, that bone which contains the rest, this has a remarkable texture and hardness above the other bones of the body, and so it serves not only as a very substantial guard to the sensory, but also, as Dr. Vieussens observes, to oppose the impulses of the ethereal matter, that there be no loss of sound, and no *confusion* in it, but that the auditory nerves may *have it* regularly conveyed to them.

The membrana tympani, as long ago as Hippocrates' time, had some notice taken of it, whether it has any disengaged part, by which it is not fastened to the bony circle, in which it is enclosed, as Monsieur Dionis affirms, is disputed. Mr. Derham could not find it. But then Dr. Vieussens discovered a further inner membrane, of very fine texture, whereof the uses are to keep the gate of the labyrinth, lest the thick air abroad hurt the pure air within, and that a due heat may be preserved in the basis of the labyrinth. But now the astonishing four little bones, and three little muscles about them, to move them, and adjust the whole compages to the several purposes of hearing, and for all manner of sounds. These were wholly unknown to the ancient anatomists. Jacobus Carpensis was he by whom the malleus and the incus were first discovered; the gentleman who was indeed the first restorer of the anatomic art, which Vesalius afterwards carried on. The stapes was found out by Johannes ab Ingrassia, a learned Sicilian. The fourth was what Francis Sylvius first lit upon.

In man, and in the four-footed beasts, they are four, curiously inarticulated with one another, with an external and internal muscle, to draw or work them in extending or in relaxing of the drum. In fowls Dr. Moulen could never find any more than one bone and a cartilage, making a joint with it, that was easily moveable.

It is a probable thought of Rohault, that for us to give attention, is nothing else but for us, by extending or relaxing the tympanum of the ear, to put it into that position wherein it shall be most *sensible of the* motion of the external air. The

benefit which deaf persons receive by loud noises, enabling to hear what shall be spoken to them in the midst thereof, helps to clear this matter. Dr. Willis tells of one who hired a servant who was a drummer, on purpose that his deaf wife might hear his discourses, which, while the drum was beating, she was able to do.

In birds the auditory nerve is affected from the impression made on the membrane, only by the intermediation of the columella; but in man it is done by the intervention of the four little bones, with the muscles acting upon them, his hearing being to be adjusted to all kinds of sounds or impressions made upon the membrana tympani; the impressions are thus made upon the auditory nerve, they first act upon the membrane and the malleus, the malleus upon the incus, the incus upon the os orbiculare and stapes, and stapes upon the auditory nerve; the base of the stapes not only covering the fenestra ovalis, wherein the auditory nerve lies, but also having a part of the auditory nerve spread upon it. Mr. Durham, upon a diligent examination, found this to be the process of hearing.

How will the wonders grow upon us, if we pass now to the labyrinth, and there survey the wonderful structure of the vestibulum and the cochlea, and yet more particularly the semicircular canals. These last are three, and of three different sizes. Valsalva thinks, that as a part of the auditory nerve is lodged in these canals, thus they are of three sizes, the better to suit all the variety of tones; and though there be some differences as to the length and size of the canals in different persons, yet lest there should be discord in the

auditory organs of one and the same man, those canals have always in the same man a most exact conformity to one another.

Shall we take notice of one curiosity more? There is one of the auditory nerves, whose branches spread partly to the muscles of the ear, partly to the eye, partly to the tongue and instruments of speech, and inosculated with the nerves, to go to the heart and breast; by means of which there is a useful and wonderous consent between these parts of the body. It is natural for most animals, upon hearing any uncouth sound, presently to erect their ears, and prepare them for the catching of every sound, and therewithal open their eyes to stand as faithful sentinels upon the watch, and be ready with the mouth to call out, or utter, according to the dictates of the present occasion; when surprised with any frightful noise, they give a shriek immediately.

Dr. Willis observes another great use of this nervous commerce between the ear and the mouth; that is, that the voice may correspond with the hearing, and be a kind of echo to it; that which is heard with one of the two nerves, may be readily expressed with the voice, by the help of the other.

Sound is the object of this admirable sense; the intricate nature of it has puzzled the best of naturalists. How many sounding instruments have yet been contrived by the wit of man, whereby sounds have been augmented, conveyed, and rendered serviceable. The largest bell in Europe is reckoned to be at Erfurt in Germany, which may be heard twenty four miles.

It is reported that Alexander the Great had a

tube, which might be heard a hundred stadia, whereof the figure is preserved in the vatican. It is a little strange that no one should hit upon the like invention, till Athanasius Kircher, in our days, and soon after him Sir Samuel Moreland, whose book was published in 1672.

Caves have out done tubes for bellowing. Olaus Magnus describes a cave in Finland, into which if a dog or any other animal be cast, it sends forth so dreadful a sound as to knock down every one that is near it; and they have therefore guarded it with high walls to prevent such mischief. Mr. Martyr informs us of a cave in Hispaniola, which with a small weight cast into it, will with its hideous noise at five miles distance endanger hearing. Kircher in his Phonurgia finds a pit in the Cucumer mountains of Switzerland, that sends out a fearful noise, and wind accompanying it; and a well in that country, a noise in which is equal to that of a great gun.

Olaus Magnus mentioning the vast high mountains of Alugermannia, tells, that the waves of the sea striking at the bottom thereof, make such a terrible noise, as not only to deafen the mariners, but also to sicken them, and very much frighten them, if they dare approach the mountains.

The prodigious cataract of Niagara, produces a noise, which perhaps nothing on earth has equaled; a noise which it might well nigh deafen one to think upon.

That the air is the medium of sound, is manifest from experiment. In an unexhausted receiver a small bell may be heard at the distance of several *paces;* but when it is exhausted, it can scarce be heard at the nearest distance: if the air be com-

pressed, a sound will be louder, proportionably to the compression, or the quantity of air crowded in; the experiment succeeds, not only in forced rarefactions and condensations of the air, but also in such as are natural. The story of the pistols discharged by Fredlichius on the Carpathean mountains, related by Varenius, gives an instance how the sound was diminished, by the rarity of the air, at the great ascent up to the atmosphere; but how magnified by the polyphonism, or the repercussions of the rocks and caverns, and other phonocaptic objects in the mount below.

Water also is capable of transmitting sound; the sound of a bell struck under water is heard, though as much more dull, and not so loud: judges in musical notes pronounce it about a fourth deeper.

Divers at the bottom of the sea can hear noises made above, but confusedly; those above cannot hear the divers below at all.

Dr. Hearn tells of guns fired at Stockholm, which were heard a hundred and eighty English miles. In the Dutch war, guns were heard above two hundred miles. If we go more southward, guns at Florence are heard at Leghorn, which is sixty five miles. When the French bombarded Genoa, they were heard at Leghorn which is ninety miles. In the insurrection at Messina they were heard at Syracuse, which is an hundred miles. This inclines Mr. Derham to think that sounds fly near as far in the southern as in the northern regions, though the mercury in the barometer does rise higher without the tropics than within the tropics; and the more northerly, still *the higher*, which may increase the sounds.

Celebrated authors differ about the velocity of sounds. Mr. Derham has by nice experiments determined, that there is a small difference in sounds before the wind and against it, and this a little abated or augmented, according to the strength of the wind; but nothing else in the world will affect it: and there is one motion to all kinds of sounds, whether loud or low; and they all fly equal spaces in equal times; and lastly, the mean of their flight is at the rate of a mile in 9 1-4 half seconds, or 1142 feet in one second of time.

The power of musical sounds over the spirits of men, yea, and over their bodies too, is very surprising. What could the famous Timothy the musician do upon Alexander? What another upon Ericus? Athanasius Kircher and Isaac Vossius, report strange things of the power which music has over the affections.

Morhoff tells us of those who would break romer glasses with their voice. Great sea-commanders have observed, that their wounded men, with broken limbs, undergo much pain at the enemy's discharges. It is well known that seats will sometimes tremble at the sound of organs.

The force of music on persons poisoned with the tarantula, is altogether astonishing!

Ismenias the Theban, by playing on the flute or harp, cured the sciatica. In the late French history of the Academy of Sciences, a man is said to have been cured of a fever and frenzy by proper tunes played to him. But after all, who but a God infinitely wise could contrive such a fine body, so susceptible of every impression that the sense of hearing has occasion for; and thus empower animals to express their sense of things to one another?

Mr. Derham thus justly concludes his discourse on the sense of hearing; "Who can survey all this admirable work, and not as readily own it to be the work of an omnipotent and infinitely wise and good God, as the most artful melodies we hear, are the voice or performances of a living creature."

Great God, let me ever use my ear to learn what thou wouldst have me to know, and shut my ear upon those things, wherewith to be unacquainted is a learned ignorance! "May I have the happiness of that experience—faith comes by hearing."

I will add one remark: Many have been born destitute of seeing; many born destitute of hearing; exposed to many inconveniences by the want of the sense of which they were destitute, however capable of being provided for. I could never learn, that any child was ever born destitute of both senses; one destitute of both could not be in any capacity of being provided for. My God, I behold thy compassion, and I adore it!

What a provision has our glorious Creator made for our smelling! the apertures of our nostrils, which are cartilaginous, and accommodated with proper and curious muscles, have, as Mr. Derham notes, all the signatures of accuracy. Here the olfactory nerves receive the odoriferous effluvia of bodies; and because the odorant particles are drawn in by breathing, the upper part of the nose is barricaded with laminæ, which fence out noxious bodies from entering the breathing passages; (for which purpose the vibrisci, or hairs placed at the entrance of the nostrils, are a notable contrivance) and they receive also the divarications of

the olfactory nerves, which are here spread very thick, and thus meet the scents which enter by the breath, and strike upon them. The more accurate the sense of smelling is in any animal, the longer these laminæ are, and the more in number, folded and crowded with the more nervous filaments, to detain and fetter the odorous particles. There are animals, the chief acts of whose lives are performed by the ministry of this wonderful sense, and these have certain points of provision, which are not in man; but, I will not say, are wanting in him: for he has enough; and he has utterly lost all sagacity, if he is not sensible of enough, to oblige his praises of the God that made him.

Our tasting is as well provided for. For the causes of tastes, and their diversities, Dr. Grew gives us a more accurate account than Theophrastus. Mr. Willis supposes that the tongue is the principal organ of taste.

There are nerves curiously divaricated about the tongue and mouth, to receive the impressions of gust, and these nerves guarded with a firm and proper tegument, which defends them from harm, but so perforated in the papillary eminences, that the tastes of all things are freely admitted there.

Admirable the situation of the taste with the smell, for the discharge of their offices, at the first entrance into the way to the grand receptacle of our nourishment: that they may therefore judge what is nourishing, and what unsavoury and pernicious.

Our most wise Creator has established a great consent between the eye, and the nose, and the tongue, by ordering the branches of the same

nerves to each of those three parts. Food undergoes the scrutiny of three senses, before it goes into the stomach.

The other senses have their peculiar seats, but feeling is dispersed through the whole body, both without and within. Every part needs to be sensible of what may be for its own safety, and therefore our most wise Creator has admirably lodged the sense of feeling in every part.

The organs of this wonderful sense, are the nerves; which are, in a most curious, astonishing, incomparable manner, scattered throughout the whole body.

Malpighi, upon many observations, has determined, that as tasting is performed by the papillæ in the tongue, so feeling is performed by the like papillæ under the skin. That these papillæ pyramidales, thrusting their heads up to terminate in the outer skin, are those by which we feel. Mr. Cowper has confirmed this, and given us elegant cuts of these papillæ, from the informations of the microscope.

Dr. Cheyne observes, the apt proportion of the sense of feeling, to the actions and impulses of the bodies among which we live, is wonderful, had the sense been ten times as exquisite as it is, we should have been in perpetual torment. Had it been many times duller and more callous than it is, we should have lost many of our most agreeable delights, and we should have had our tenderest parts consumed without knowledge or concern.

We were but now pretty near the teeth; of these the numbers are thirty two. But Oh, how many more the wonders! Galen observes, we *commend* the skill and sense of him that shall

well marshal a company of thirty two: and shall we not admire him who hath so admirably disposed these thirty two?

We will here single out eight or nine things, that are very remarkable: the teeth continue to grow in their length as long as we live, as appears by the unsightly length of a tooth, when the opposite happens to be pulled out. Thus providence repairs the waste that is daily made of the teeth, by the frequent attrition in mastication. That part of the teeth, which is above the gums, is not invested with the sensible membrane, called periostium, with which the other bones are covered; but then the teeth are of a closer and harder substance than the rest of the bones, that they may not be so soon worn down by grinding the food. For the nourishing of these necessary bones, the glorious Creator has wonderously contrived an unseen cavity in each side of the jaw-bone, in which are lodged an artery, a vein, and a nerve, which through lesser gutters send their twigs to each particular tooth. But because infants are to feed a considerable while upon milk, and lest their teeth should hurt the tender nipples of the nurse, nature deters the production of them for many months; whereas divers animals, which must seek betimes a food that needs mastication, are born with them. The different figure of the teeth, how surprising! the fore-teeth, called incisores, broad, with a thin and sharp edge, to cut off a morsel from any solid food. The eye-teeth, called canini, stronger, deeper, and more able to tear the resisting sort of aliments. The jaw-teeth called molares, flat, broad, uneven, accommodated with little knobs, to hold, and grind, and mix the aliments.

Because the operations, to be performed by the teeth, sometimes require a considerable strength, with what strong muscles is the lower jaw provided! and every tooth is placed in a strong, a close, a deep socket; and the teeth are furnished with holdfasts, that are suitable to the stress, which in their different offices they may be put to. The fore-teeth and the eye-teeth have usually but one root, which in the latter, is very long; but the grinders, that must manage hard bodies, have three roots, and in the upper jaw often four, because these are pendulous, and the jaw somewhat softer. How convenient the situation of the teeth! the grinders, nearest the centre of their motion, because the greatest force is required in them; the cutters, where they may readily cut off what is to be transmitted to the grinders. Finally, the jaw, that is furnished with grinders, has an oblique or transverse motion, which is necessary for the comminution of the meat: but this motion is not in the jaw of animals, which have not such teeth belonging to them.

"Temperance in feeding, is one special article of the homage we owe to the glorious One, who has, in our teeth, so displayed his admirable workmanship!"

And we are now not far from the tongue, the uses whereof are, how various, how marvellous! and the texture how much to be wondered at! You were in the right of it, Vesalius, when you told us, that no mortal had ever yet thoroughly considered all the wonders of it.

This is the main organ of tasting; it helps also in the mastication, and the deglutition of the food. Here the spittle has its vent; which though

commonly taken for an excrement, is indeed an humour wonderfully serviceable; because a great part of our food is dry, there are provided several glandules, to separate this juice from the blood, and no less than four pair of channels to convey it into the mouth, which are lately found out, and called the ductus salivales; and through which the saliva continually distilling, serves to macerate our food, and by tempering it, render it fit for chewing and swallowing. And hereby also the concoction in the stomach is not a little promoted.

But the grand glory of the tongue is, that it is the main instrument of speaking; and therewith we bless God, even our father! this is a faculty peculiar to man: it was never known that a beast could attain to any thing of it. A bird indeed has been taught now and then a few words, and with no little difficulty; but then he understands not the meaning of his few words, nor does he use them for signs of things conceived by him. The most that can be pretended, is, that a parrot being used to such or such enjoyments or afflictions, at the prolation of certain words, may express his passions by the noise of these words. The Jewish rabbins were not so very absurd in defining man, a creature that speaks. By the way, "you that are stammerers ought exceedingly to humble yourselves before the holy God, under his rebuke upon you, in an organ, which, well employed, would be your glory. Our Saviour, seeing a man that had an impediment in his speech, he sighed upon it; no doubt it grieved him to see a man so marked by the displeasure of God, in a most sensible wound upon so distinguishing a faculty. My friends, learn to speak deliberately. This

expedient alone would help you wonderfully; for in singing there is no stammering. Speak but little, do not affect a loquacity; a folly your tribe are often subject to! though it is more burdensome and ungrateful in them, than in other people. What little you speak, let it be very wise, very good; such as may bespeak some respectful regard for what you say. Then be not altogether discouraged, under your calamity: a Moses, a Paul and a Boyle, will make a noble triumvirate of companions for you, under your uneasy infirmity." I go on: the necessity of the tongue for speech will remain generally to be asserted, notwithstanding the tricks of the ventriloqui, taking advantage of the duplicature of the mediastinum, to form various voices.

What the emperor Justinian asserts in his rescripts, that he saw venerable men, who, when their tongues were cut out at the very root, yet continued plainly speaking the truths of Christianity against the Arians; a fact of which many witnesses are subpœnaed by Cujacious: it looks miraculous.

My God, thou hast made man's mouth. Make thou the speech of mine what it ought to be; a pure language. I have said, I will take heed, that I do not sin with my tongue. Assist me to keep such a resolution, and abhor all rotten or faulty communication. I resolve that my mouth shall speak the praise of the Lord. O that my tongue may be like choice silver, for the good use and worth of what is thereby articulated, and as a tree of life in all my conversation.

If we pass down from the mouth, we are quickly entertained with a wind-pipe, which is all made

up of wonder. A continual respiration is necessary for the support of our lives; it is therefore made with annulary cartilages, to keep it constantly open, and that the sides of it may not flag and fall together. And lest, when we swallow, our meat or drink should fall in to do mischief there, it hath a strong valve, an epiglottis, to cover it when we swallow. For the more convenient bending of our necks, it is not made of one continued cartilage, but of many annular ones, which are joined by strong membranes; and these membranes are muscular, compounded of straight and circular fibres, for the more effectual contraction of the wind-pipe, in any violent breathing or coughing. And that the asperity of the cartilages may not hurt the gullet, which is of a tender and skinny substance, or hinder our swallowing of our food, these annulary gristles are not entire circles; but where the wind-pipe touches the gullet, there the circles are fitted up with only a soft membrane, which may easily give way to the dilatation of the gullet. But now to proclaim a plain design in this conformation, as soon as the wind-pipe enters the lungs, its cartilages are no longer deficient, but perfect circles; it was no longer necessary they should be deficient, it was more convenient they should be perfect. And then, to finish the collection which the excellent Mr. Ray has made (for I have him now before me) of these curiosities, for the various modulation of the voice, the upper end of the wind-pipe, is endued with several cartilages and muscles, to contract or dilate it, as we would have our voice flat or sharp; and the *whole* is continually moistened, with a glutinous *humour* issuing out of the small glandules, that

are upon its inner coat: so it is fenced, that neither the air drawn in, nor the breath going out, may hurt it; yet it is of so quick a sense, that it is provoked easily to cast out, by coughing, whatever may be offensive to it.

Caspar Bartholin has further observed that, where the gullet perforates the midriff, the carneous fibres of that muscular part are inflected and arcuate, as a sphincter embracing it, and closing it fast; which is a sensible providence, lest in a perpetual motion of the said midriff, the upper orifice of the stomach should gape and cast out the food as fast as it received it.

Dr. Grew observes, that the variation in the wind-pipe is observable in every creature, according as it is necessary for that of the voice; and the rings of the wind-pipe are fitted for the modulation of the voice.

The faculty of the glottis, in so exquisitely contracting, or dilating of itself, as to form all notes, is, as Mr. Derham says, prodigious. For, as Dr. Keil notes, if you suppose the greatest distance of the two sides of the glottis, to be one tenth part of an inch, in sounding twelve notes, to which the voice easily reaches, the line must be divided into twelve parts, each of which gives the aperture that is requisite for such a note with a certain strength. But if we consider the subdivision of notes, into which the voice can run, the motion of the sides of the glottis will be still vastly nicer. A voice can divide a note, at least into an hundred parts, which a just ear can perceive; but then it follows, that the different apertures of the glottis actually divide the tenth part of an inch into *twelve hundred* parts, and a good ear will be sen-

sible of the alteration. But because each side of the glottis moves just equally, therefore the divisions are double, the sides of the glottis, by their motion, do actually divide one tenth part of an inch, we must say, into two thousand and four hundred parts.

My God, I desire that never any evil word may have my leave to go through so curious a passage, and that the dispositions of my mind may not be so vicious and odious, as to render so elegant a passage, the vent of an open sepulchre. "It is fit that nothing but confessions of God, and kindnesses to men, should have such an exquisite passage found for them."

We cannot leave these parts, without considering respiration. A faculty of such importance to life, that in the sacred oracles, and indeed in our common phrase also, breath and life are so concomitant, as to be equivalent: Lord, thou takest away their breath, and they die.

The uses of respiration were but indifferently assigned, till Malpighi's discoveries. Willis and Mayow and others, mention uses thereof that are not contemptible; but Thurston rejects the opinion of their being the principal, and thinks it is principally to move, or pass the blood, from the right to the left ventricle of the heart. Experiments made, by divers ingenious men, on strangled animals, have demonstrated his opinion: for which cause the learned Etmuller also espoused it, who having reckoned up no less than thirteen uses of respiration, which are of great consequence, but conduce rather to the well being, than the existence of the living creature, he concludes with a fourteenth, as the chief of all, which

is, for the passing of the blood through the lungs, that is thrown into them by the heart. Dr. Drake not only establishes this notion of respiration, but carries it further, and makes it the true cause of the diastole of the heart; which neither Borelli, Lower, nor Cowper, much less any before those eminent persons, have well accounted for. Dr. Lower has proved, that the heart is a muscle; the motion of all muscles does consist in constriction. This accounts for the systole: but the heart has no antagonist muscle. What shall we now do for the diastole? Great wits have been puzzled here. But Dr. Drake makes the weight of the incumbent atmosphere to be the true antagonist for all the muscles; which serve both for the constriction of the heart, and for ordinary respiration.

Dr. Cheyne adds yet one use more for this great faculty and action; that is, to form the elastic globules, of which the blood does principally consist, and without which there would be a general obstruction in all the capillary arteries.

Dr. Wainwright observes, the air cannot remain in the lungs, without being much heated, and thereby having the spring of it unbent, and so become specifically lighter than the external air: for which reason it will, by a known principle in mechanics, give place to it, and rise to such a hight, as till it meet with air of its own weight, and there it will remain. But then the sides of the blood-vessels, which by the inflation of the lungs were drawn asunder, now when the lungs are crowded on a heap, will be forced together, and so the blood contained in them will be broken into innumerable parts, exceeding small, and thereby rendered more fit to pass the several strainers of the body.

Great God! thou hast in thy hand my breath and all my ways; I resolve to serve thee as long as I breathe; I resolve to look on thy service as the end for which thou dost continue my breath; I resolve to employ my breath in thy service to the last: I will praise thee as well as I can to and in my last breath; and when I have no breath, I shall do it better.

Behold now the lungs, a most surprising piece of workmanship! consult the description of them given by Malpighi, who first of all discovered their vesiculæ; and by Willis, who, writing after him, has proceeded upon it yet more accurately, and by Cowper in his admirable tables. Then stand and admire the work of God.

While the fœtus is yet in the womb (as Dr. Keil observes) the vesicles of the lungs lying flat upon one another, compress all the capillary blood-vessels, which are spread upon them. As soon as we are born, the air, by its gravity and elasticity, rushes into the empty branches of the trachea arteria, and blows up the vessels into spheres: by which means the compression being taken off from the blood-vessels, and they equally expanded with the lungs, all the blood has a free passage through the pulmonary artery. But when the air is thrust out again, by a contraction of the cavity of the thorax, it being a fluid body, compresses the vesicles and blood-vessels upon them, every where equally. By this compression, the red globules of the blood, which through their languid motion, in the veins, were grown too big to circulate in the fine capillary vessels, are broken, and again divided in the serum, and the blood is made fit for nutrition and secretion. This pressure of

the air on the blood-vessels, Dr. Keil says, is equal to an hundred pounds weight. It is also probable, he thinks, that particles of the air must enter the blood-vessels, and mix with the blood in the lungs.

The Divine workmanship about the heart, who, that has any heart, can forbear admiring, with most sensible acknowledgments! This is that admirable bowel, which with its incessant motion distributes the blood, the vehicle of life, throughout the whole body. From this fountain of life and heat, there are conduit-pipes, even to the least, yea, and most remote parts of the body. It is the machine, which receives the blood from the veins, and forces it out by the arteries, through the whole body. The force with which the heart squeezes out the blood into the arteries, is, in Borelli's reckoning, equal to the force of three thousand pounds weight. For this important use it is most exquisitely contrived. Being a muscular part, the sides of it are composed of two orders of fibres, running circularly or spirally from the base to tip, contrarily the one to the other; and so being drawn contrary ways, do violently constringe and straiten the ventricles, and strongly force out the blood. And then the vessels, we call arteries, which carry from the heart to the several parts, have their valves, which open outwards like trap-doors, and give the blood a free passage out of the heart, but will not suffer any return of it thither; and the veins, which bring it back from the several members to the heart, have their valves, or trap-doors, which open inwards, and give way for the running of the blood into the heart, but prevent its running that *way back again.* Moreover, the arteries consist

of a quadruple coat, the third of which is made up of annular, or orbicular, carneous fibres, to a good thickness, and is of a muscular nature, (which was first observed by Dr. Willis) and this, after every pulse of the heart, serves to contract the vessel successively with incredible celerity; so by a kind of peristaltic motion, forcibly and very swiftly impelling the blood onwards to the capillary extremities, and through the muscles; wherefore the pulse of the arteries is not caused only by the pulsation of the heart, which drives the blood through them after the manner of a wave, as many would have it, but also by the coats of the arteries themselves, as it has been confirmed by the experiments of many modern physicians, yea, and of Galen also. We may add one thing more, that the heart and the brain do notably enable one another to work; for the brain cannot live unless it receive continual supplies of blood from the heart, much less can it perform its functions of preparing and of dispensing the animal spirits; nor can the heart afford a pulse, unless it receive spirits or something descending from the brain by the nerves: do but cut asunder the nerves that go from the brain to the heart, the motion thereof ceaseth immediately.

For the motion of the heart, Monsieur Tauvry flies to a subtile matter managing the fibres of it, but seems to acknowledge it a matter which no mortal has traced yet to satisfaction. In fine, the heart is a compound muscle, and each ventricle of it will (as Dr. Keil observes) contain an ounce of blood. We may well suppose the heart throws into the aorta an ounce of blood every time it contracts; the heart contracts four thousand times in

one hour, sometimes more, sometimes less; hence there passes through the heart every hour four thousand ounces of blood, that is to say, three hundred and fifty pounds. Now the whole mass of blood is no more than twenty five pounds, so that a quantity of blood equal to the whole mass passes through the heart fourteen times in one hour, which is about once in every four minutes; not the whole mass itself: we do not suppose that the blood which goes to the extremities, can return to the heart as soon as the blood which goes only to the kidneys or the liver.

"Without making any fanciful excursions upon metaphors drawn from the figure and office of the heart, I am sure that I should behold it with a most hearty and lively sense of my obligations to give thee my heart, O my God, and love thee with all my heart!"

The stomach has many things that are truly admirable! The greatest philosophers have cried out, "how great a comprehension of nature did it require to make a menstrum that should corrode all sorts of flesh coming into the stomach, and yet not the stomach itself, which is also flesh!" It is membranous, and capable of being dilated or contracted, according to the quantity of meat contained in it; the situation of it under the liver, accommodates with a heat, that carries on the concoction; when it has gone through with the concoction, it can shrink itself, and cast out the food. But, concoction, how performed? There is in bodies a principle of dissolution, which upon the extinction of their vital and vegetative faculty, begins to exert itself towards the destruction of the subject. *This principle* of corruption is, perhaps, the same

that in a state of circulation and vegetation was the principle of life, but now being denied that passage which it had before, it makes its way irregularly, and so destroys the continuity of the solids, in which it is included, and introduces that change in the whole mass which is called corruption. This active principle is a sort of air, which is mixed in a considerable quantity with all sorts of fluids; this (though its natural and essential motion be expansive or quaquaversum) when it is introduced into bodies, has two kinds of motion, one expansive, by which it communicates that intestine motion which all juices have, and by which the containing parts are gradually extended, and have their growth; but the other progressive, and indeed circulatory, which is occasioned by the renitency of solid parts, and obliges its taking that course which is most open and free. This motion being stopt, the expansive still remains, and continues to act, till by degrees it hath so far overcome the resistance of the including bodies, as to bring itself into an equal degree of expansion with the external air, which cannot be done without a destruction on the texture and continuity, or specific degree of cohesion of the solids; and this is called a state of corruption. This destructive quality of the air in bodies may be promoted, either by weakening the tone of them, and the cohesion of the parts, and so facilitating the work of the air, as it is done when fruit is bruised; or by intending the expansive force of the air itself with heat, or other co-operating circumstances. The former is done in mastications, the latter by the heat of the stomach, which forcibly rarefying the air, enables it to rend the including bodies to

pieces the sooner, and so to let loose the fluids, and perhaps likewise produce a comminution upon several parts of the solids, so as to make them sustainable in the liquor; which latter is the operation that completes the digestion in the stomach.

In stewing, though the heat be unspeakably short of what it is in roasting and boiling, the operation is of all the quickest, because it is performed in a pretty close vessel, and full, by which means the succussions are more often repeated, and more strongly reverberated. The operation of the stomach is mightily resembled by the digester of Monsieur Papin; in this the meat is put, together with so much water as exactly fills the engine, the lid is then screwed on so close as to admit of no external air, and with two or three lighted charcoal, or the flame of a lamp, it is reduced into a perfect pulp, or indeed a liquor, in a very few minutes, in six, eight, ten, twelve, or sixteen, according to the toughness of the matter to be digested, or the augmentation of this little fire; this way even the hardest bones are presently dissolved. Thus the stomach naturally closes on the aliments, which descend to it; it strictly embraces them when it is full; by keeping out extraneous air, it fortifies and invigorates the succussions of that which is contained in the aliments, and this is enabled hereby to break and resolve the bodies which included it, into particles that may be small enough to enter the lacteals. When all the chyme and chyle is pressed out, the stomach, which follows the motion of its contents, is again, by means of its muscular coat, reduced into a state of contraction, and the inner is brought thereby to lie in folds, and by means of the peris-

taltic motion rubbing lightly upon one another, produce that sense of a vellication which we call hunger: this being felt first in the upper orifice, which is first evacuated, begins first therefore to prompt us to replenishing; but as by degrees the remainder of the contents are expelled, this friction of the membranes upon each other, spreads gradually over the whole stomach, and renders our hunger more impatient.

Great God, I bless thee for all my food. My gracious Feeder, I bless thee that I have not known the terrible famine. I will take no food without looking up to thee for thy blessing, by which alone I live.

The intestines; these receive the chyle from the pylorus; these further digest it, prepare it, separate it: these, by their peristaltic motion, drive it into the lacteals; but the excrementitious parts they send off elsewhere, from whence there is no regress, unless upon a relaxation or laceration befalling the valve of the colon. Can you behold the structure of the intestines, as reported by Kerkringius, Glisson, Willis, Peyer, and others, without astonishment?

The intestines, it is wonderful, are six times as long as the body to which they appertain; and now that they should keep their tone, and their site, and hold on during their office, and give an undisturbed passage to what every day passes through them, and this for some scores of years together, it is impossible for me to consider it without falling down before the glorious God, and making that acclamation, What hast thou done *in me*, O thou Preserver of men! How much do *I* depend upon thee for my preservation from grievous diseases!

The liver does admirable things, in continually separating the choler from the blood, and emptying it into the intestines, where it is useful, not only to provoke dejection, but also to attenuate the chyle, and render it so subtile and fluid, that it may enter at the orifices of the lacteals.

The bladder is an admirable vessel; the substance is membranous, and extremely dilatable, for the receiving and containing of the urine. It hath shuts for the ends of the ureters, which are so artificially and marvellously contrived, as to give the urine a free entrance, but stop all passage backward: the wind itself cannot be transmitted through the shuts, though never so strongly forced upon them.

In the kidneys, how admirable the innumerable siphons, the little and curious tubes, conveying the urinous particles into the ureters, discovered first by Bellini, afterwards illustrated by Malpighi.

Leuenhoeck has discovered vessels in a human body, the diameters whereof are more than seventy nine thousand times less than an inch; and, as Dr. Wainwright observes, at least so small must be the diameters of the lacteals. My God, how exquisite, how curious are thy works! but then how much do I depend upon thee to keep all the vessels of my body, doing their office in order!—that so fine an engine is not ruined a thousand times in a day, but holds on its motion for twenty five thousand five hundred and sixty seven days.

All the glands of the body, each of them an admirable congeries of many vessels, in a stupendous variety, curled, complicated, circumgirated, and marvellously woven into one another; these

give the blood an opportunity to stop a little, and separate through the pores of the capillary vessels into the secretory ones, which after all exonerate into one common ductus. Read Wharton, Bartholin, Bilsius and others; but prepare always for a field of wonders, equal to any in the field of Zoan—But then consider too the variety of humours that are separated by the glands; all different in colour, taste, smell, and other qualities.

The bones, how admirable in their circumstances! the back-bone is contrived with an artifice truly astonishing. It is divided into many vertebres, for the commodious bending; one entire and rigid bone of that length would have been often in danger of snapping; it is tapering, in the form of a pillar, the lower vertebres being the broadest and largest, the superior in order less and less, so that the trunk of the body may have the greater stability: but the several vertebres are so elegantly united, that they are as firm and strong as if they were but one single bone; they are all perforated in the middle, with a large hole for the spinal marrow to pass along, and each of them hath a hole on each side, to transmit the nerves to the muscles of the body, and thereby convey both sense and motion. By the close connexion of the vertebres, the back-bone is formed so as to admit of no great flexure and recess from a right line; it also admits no angular, nor any but a moderate circular bending lest the spinal marrow should be compressed, and so the passage of the spirits to and fro meet with some obstruction.

Dr. Grew observes, that in trees there is a new *ring* added every year out of the bark to the wood; so too in animals, while they grow, there is a new

periostium added from time to time out of the muscular membranes to the bones. The sweet harmony with the vast variety in the works of God.

Admirable the provision that is made for the more easy and expedite motions of the bones in their articulations: a twofold liquor is prepared by the inunction whereof their heads or ends enjoy some lubrification; first, there is an oily one, furnished by the marrow; and then there is a mucilaginous one, furnished by certain glandules, that are seated in their articulations; both of these together make up the most proper mixture for this purpose that can possibly be thought upon; both of the ingredients are lubricating. But more than this, from their composition they mutually improve one another; the mucilage adds to the smoothing efficacy of the oil, and the oil preserves the mucilage from inspissation, and from contracting the consistency of a jelly. Hereby the motion of the bones is facilitated; for if they were dry, they would not readily obey the pulls of the motory muscles, which we find in the wheels of our clocks; the ends of the bones are hereby also kept from an inconvenient incalescency, which if they were dry, being so hard, a swift and long motion would necessarily give to them; and thus the wheels of our coaches must be besmeared with a mixture of grease and tar, that they may not be set on fire. What a slothful world must we have had, and how confined to deliberation, if this care had not been taken of our bones! and finally, a great mischief is now prevented, the ends of our bones are not worn down, by a grievous attrition in their motion rubbing against one another; it is indeed a strange thing that this

proves a sufficient preservative to prevent the consumption of the bones, when we see the tops of teeth, which are harder, worn off by mastication, and brought so low, that the very nerve lies bare, and for mere pain they can be used no more. The ingenious Mr. Havers, who makes these remarks in his osteology, makes this conclusion: here we cannot avoid the notice of the visible footsteps of an infinite reason, and we can never sufficiently admire the wisdom and providence of our great Creator.

We may add, wonderful the construction of the bones, that are to support the body, or bear heavy burdens, or be employed in difficult exercises; they are made hollow, this wonderfully accommodates them for both lightness and stiffness; a hollow body is more inflexible than a solid one, of the same substance and weight: but the ribs, which do not carry loads nor do any thing wherein so much strength is required, but are only to fence the breast, have no cavity in them, and these towards the fore part of them, are broad and thin, so that they may give way, without much danger of any fracture; and they by their elastic property again return to their figure: and yet the hollow of the bones is not useless, but it contains the marrow, which supplies an oil, for the maintaining and inunction of the bones, and of the ligaments, and facilitating their motion, and to secure them from disruption, to which they would by any sudden contortions be otherwise obnoxious. The mention of the ribs will bring on one observation more; that although the breast is encompassed with ribs, the belly is left free; this is, that it may give way to the motion of the midriff

in respiration, and to the necessary reception of food, and to the convenient bending of the body. Great God, all my bones must say, who is like to thee? I bless thee for that thou dost not chasten the multitude of my bones with strong pain.

It cannot be without admiration looked upon, that all the bones, and all the muscles, and all the vessels of the body, should be so contrived, so adapted and compacted, for their several motions and uses; all according to the strictest rules of mathematics! if you attempt an innovation or alteration, you mar all instead of mending any thing. In the muscles alone there is more geometry than in all the artificial engines in the world; the greatest mathematicians have not found a nobler subject for their disquisitions and contemplations than animal motion. The essays of Croon, and Steno, and Borelli, on that subject, have been very curious.

Dr. Grew observes, that no less than forty or fifty muscles, besides many other subservient parts, go to execute that one act of laughing; certainly then laughing for nothing may be indicted for an act of folly! He goes on with his observation, that in some cases we cannot execute one single thought without such a retinue. Suppose one sitting in a room has a thought of looking at something out of a window, that one thought has immediately seventy or eighty muscles put into motion to wait upon it; so that, says the doctor, there is not a monarch upon earth served with such majesty as every man is within the territory of his own body: but then how reasonable is it, O man, for thee to serve the Maker *of all these*! glorious God, I will do it with all *my muscles*, with all my powers.

Dr. Grew has a further observation; what can be more admirable, than for the principles of the fibres of a tendon to be so mixed as to make it a soft body, fit both to receive and impart the species of sense, and to be easily nourished and moved, and yet with such a softness to have the strength of iron.

Those muscles which appear as contemptible as any of the body, even the muscles of the belly, though Galen, and other anatomists after him, have contented themselves with reckoning four or five uses of them, they are indeed more than can be reckoned. Dr. Grew has employed almost a large page in the enumeration.

It is admirable that under our skin there should be such an unknown variety of parts, and so variously mingled, all so packed that there is no unnecessary vacuity in the whole body, yet so far from clashing with and hindering of one another, that they do all in the most friendly manner conspire to assist one another, and concur in the general design, which is the preservation of the whole. Behold, arguments of infinite Wisdom and counsel! he must be worse than mad, that can find in his heart to imagine all not provided by a most wise and intelligent cause.

Every part is clothed, joined, corroborated by membranes, which are capable of a prodigious extension; those of the peritonæum are a particular instance of that, out of which alone, in hydropical persons, there have been drawn forty gallons of water, by a paracentesis. The undoubted authorities of Tulpius, and Blasius, and other physicians, oblige us to believe surprising things *of this* importance.

It is notable, that all our organs are involved in coats, one or more, consisting of tough or muscular fibres, intended not only to protect them, as has been commonly thought, but also by a due constriction to assist them in straining off their several contents.

These parts which at first appear to be of no more use than to fill up empty spaces, will upon examination be found exceeding serviceable. The fat serves to cherish the body, and keep it warm; yea, will maintain it for some time, when food is wanting, and be as a sulphurous pabulum, to preserve the heat of the blood. By what vessels the fat comes to be separated from the blood, is a point of curious inquiry; the collection of it more on some certain parts (as the caul and the reins) than on others, appears to be for the cherishing of those parts with warmth; the caul is like an apron of woollen cloth to the lower belly. The gladiator, whose caul was cut out by Galen, felt so much cold, that he was forced constantly to keep his belly covered with wool. The intestines containing much food, there to undergo its last concoction, and vessels of blood not flowing thither, need such a covering to defend them; doubtless a constant heat is required about the reins, for the separation of the urine from the blood: for we see if the blood be chilled, the secretion of the urine will be sensibly stopt, and the serum cast upon the glandules of the mouth and throat.

Monsieur Bernoulli, in a curious meditation about muscular motion, has observed another thing, that must not be omitted; that in muscular *motion the* expense of animal spirits is not in pro-

portion to the labour which the animal is at: and so a man reduced to hard labour, is not reduced to the necessity of having twice or four times as much victuals as one that is under no such necessity of working. Now the spirits are the most precious things in all the animal body, we live by them; so needful and useful a substance was to be saved by all the means that were possible. And behold, as Dr. Cheyne expresses it, we see the wise Author of nature has taken care that no expenses should be made that could be avoided.

It has been observed by some, that to provide matter for the generation of spirits in man, a vast quantity of blood is prepared, far exceeding what is found in other animals. The blood for the body of man bears the proportion to his weight, of one to ten; in other animals it is but one to twenty. And for the fetching of spirits out of this matter, there is the laboratory of the brain, which in a man is twice as much as in a beast four times as large.

It is Dr. Cheyne's proposition, that the strength of animals is in a triplicate proportion to the quantity of blood running in the vessels.

The lympha of the blood is a marvellous thing; a liquor separated in the membranes and glandules, which is the medium whereby the serous and fibrous parts of the blood are united, and the bones and membranous parts of the body are nourished. But how marvellous the lymphatic vessels, which convey this exquisite liquor. They disappear when the animal dies; their number is unaccountable: they were first of all discovered by Thomas Bartholin and Olaus Rudbeck, in the years 1650 and 1651. Pecker made a progress

in the discovery of them; and their valves were demonstrated by Frederick Ruysch, which permit this transparent liquor to pass through them towards the heart, but are like shut floodgates upon the returning; they rise in all parts of the body. The glands that separate the lympha are of the smallest kind, and scarce visible by the finest microscopes; but the lymphaducts unite with one another, and grow larger as they approach the heart; and yet they do not, like the veins, open into one common channel.—The whole contrivance of these fine vessels, who can behold without amazement!

About the blood, this is admirable. The branches which go off at any small distance from the trunk of an artery, unite their channels into one trunk again, whose branches likewise communicate with one another, and with others; whence it comes to pass (as Dr. Keil observes) that when any small artery is obstructed, the blood is brought by the communicating branches to the parts below the obstruction, which must otherwise have been deprived of their nourishment. And in the veins there is the like provision, that so justly surprises us in the arteries.

The viscidity of the blood is increased by the heat in a fever; if we apply a much less degree of heat than will boil water, it will turn the serum into a jelly; the heat of the skin, where the pulse will beat sixty strokes in a minute, is to the heat of boiling water as 16 to 52; boiling water is but little more than three times as hot as the blood of an healthy man. If the heat of the blood increase in proportion to the beat of the pulse (as it must, *if it beat with* the same strength it did) a man

whose pulse beats 195 strokes in a minute, would be as hot as boiling water; now 120 strokes is common. Behold whence the siziness of the blood in inflammatory distempers!

"Why should I sinfully over-heat my blood? But since my life depends on the good constitution of this red liquor, which is yet so easily depraved, so easily disturbed, so easily overturned; O God of my life, I wonder that I live! I desire to live as a dying man, but I live, because thou art the God of my life."

But at last the instrument all this while employed in writing these things, demands of me that it be not forgotten. The hand is divided into four fingers, bending forwards, and one stronger than any of them that bends backwards, to join with them; it is fitted thus to lay hold on objects of any shape, size or quantity; and sometimes one finger alone can discharge many offices: the fingers are strengthened with several bones, jointed for motion, furnished with muscles and tendons, to bend them circularly forwards; how convenient this for the holding and griping of any object! the fingers also have their muscles, to extend and open the hand, and move them to the right and left; and thus the whole hand may be employed, as all of a piece.

The tendons bending the middle joint of the fingers are so perforated, as to give passage to the tendons of the muscles which draw the uppermost joints, and all bound close down to the bone with strong fillets, like so many bow-strings, lest they should start up, and hinder the hand in its operations: finally, the ends of the fingers are fortified with nails, to adorn them as well as defend

them; yea, and have their further uses too, if what Camillus writes in his treatise upon the forming of judicia medica from the inspection of the nails, may be relied upon: and how thin the skin, and how exquisite the sense at our finger's ends, by which we may judge of what we have there to be handled!

The uses of this astonishing instrument cannot be reckoned up; a whole book written by it, might be easily filled with an enumeration of its uses. Aristotle says well, they do ill who complain that man is worse dealt with than other creatures, who are born with natural weapons to defend themselves, and offend their enemies; a hand, with reason to use it, abundantly supplies the uses of all those natural weapons; it is a horn, a hoof, a claw, a tush and all! Dr. Grew says very truly, never was there made an instrument so curious! the sixteen several general motions of it are the elements of operation, as the letters are of speech; how infinitely to be diversified! what shall we call this but the handy work of our God!

"When I apply my hand to any action which could not be done without it, I have my mind invited to such a thought upon it; great God, I bless thee for arming me with so curious and so adapted an instrument! may I never ungratefully put forth my hand to an evil action."

"Such a thought often rolling in my mind, and ruling my hand, would be a better token for good to me, than the most promising lines of any silly chiromancy."

Voluntary motion should not be left unconsidered; whereof Dr. Cheyne observes, the only

conception we can form, is, that the mind, like a skilful musician, strikes on that nerve which conveys animal spirits to the muscle that is to be contracted, and adds a greater force than the natural to the nervous juice, whereby it opens its passage into the vesicles, of which the muscular fibres consist; but this action of the mind or will on these animal spirits, is altogether unaccountable from the laws of motion. My God, in thee I move! the astonishing power of spontaneous motion is what thou hast given me! Oh, may I never employ it in any acts of rebellion against Him that gave it.

Certainly men may do well also to consider, whether the very configurations of several parts, may not afford good and great admonitions of morality to them. I need not explain myself, when I offer a hint I have somewhere met with: ponder, O man, what parts of thy body have bridles of nature upon them.

Some consideration is also due to the astonishing strength with which the bones of men have been sometimes endued. The strength for which a Samson has been so famous, was indeed owing to a possession and assistance of a spirit entering into him from above; but the ordinary strength of our nerves, exerted in moving and lifting, is truly admirable; the force of the nervous fluid! and the ability of the little fibres, to sustain what it puts them on! and there are now and then, since the days of Milo the ox-carrier, examples of strength, which will yet more strongly call for our growing admiration; it would swell my essay so large, that it would require a man of such strength to carry it, if on this and other occasions I should

insert all that has occurred to our purpose, in Valerius Maximus, in Cælius Rhodiginus, in Zuinger, in Camerarius, in Hakewell, in Wanly, and in other collectors; however, a touch or two may not be unacceptable.

The tyrant Maximus would with his hands draw loaden carts and wains, break the bones of horses, and cleave trees asunder. Marius, who of a cutler became an emperor, could with his fourth finger stop a cart that was drawn with horses, and force it backwards; and a fillip of his finger (which they also report of Tiberius) would knock a man down like a blow of a hammer. One Salvius, mentioned by Pliny, having a hundred pounds weight at his feet, and as many in his hands, with twice as much on his shoulders, would go up a flight of stairs. George Castriot with his massy scimitar did amazing executions, he cut the Turks to pieces, Barletius affirms, three thousand of them with his own hands, and scorned ever to throw away more than one blow upon an object; he could cleave helmet and harness, as if they were but straw before him. Cardan saw one dancing with two in his arms, two on his shoulders, and one hanging about his neck. A baron of Mindelheim would with his middle finger do things that surpass imagination; he would shove a cannon where he pleased; he would break horse-shoes with his hands like potsherds; (which is a circumstance they only relate of Pocova, a Polish gentleman.) Little Venetianello would with his hands writhe great pins of iron, as if they were softened with the fire, and carry on his shoulders an erect beam of twenty feet long and a foot thick, and shift it with-

out the use of hands, from one shoulder to another. A provost at Misna would make nothing with his bare hands to fetch a pipe of wine out of a cellar, and lay it on a cart. Mayolus affirms he saw a man who took a pillar of marble three feet long, and one foot in diameter, which he cast up very high into the air, and received it again in his arms, and played with it as a little ball; and another who would break a cable as large as a man's arm, as easily as if it were a thread of twine. Froisard, a faithful historian, tells of a man who would make nothing to carry a great ass, with all his load, upon his back. The stories we have of the mighty burdens carried by some of the Cornish men, related by Mr. Carew, and others, are truly wonderful.

Can we now do any other than fall down before the glorious God, who has given such strength to the children of men, as if their strength were the strength of stones, or their flesh were brass; (and yet, when God pleases, crushed before the moth!) with the ancient adoration, O Lord God of hosts, who is a strong god like to thee.

But in man, must that have the last consideration, the state whereof, alas, is that which too commonly is the last considered! the soul, which has mustered the many thoughts wherewith our Christian philosopher has filled his pages, must now be thought upon. But oh, how much is the Father of spirits to be herewith acknowledged and glorified!

The stupendous faculties of the soul! the wisdom, with which a soul may perform wonderful things. It is the wisdom that God puts into the *heart* of a Solomon.

The performances of that reaching philosophy, with which we have seen sagacious minds endued, have been amazing. The performances of the politician, have sometimes been as amazing as those of the philosopher. Men of a great soul, what astonishing things have they arrived to! and yet I will venture to say, the love of God in the soul, or a principle of grace infused into it, is a divine workmanship, that is more noble than all its other faculties, and will unspeakably ennoble them all.

I have read, in the ascetics, of a servant of God, a passage of this importance: "I am able to write in seven languages; I feast myself with the sweets of all the sciences, to which the more polite part of mankind ordinarily pretend. I am entertained with all kinds of histories, ancient and modern. I am no stranger to the curiosities, which by all sorts of learning are brought to the curious. Nevertheless, it appears to me more valuable than all this, it appears more delectable, it is a thing of a superior character, with a true spirit of charity, to relieve a poor, mean, miserable neighbour; much more to do any extensive service for the redress of those epidemical miseries, under which mankind in general is languishing, and to advance the kingdom of God in the world."

Reason, what is it but a faculty formed by God in the mind of man, enabling him to discern certain maxims of truth, which God himself has established, and to make true inferences from them? In all the dictates of reason there is the voice of God. Whenever any reasonable thing is offered, I have God speaking to me. Behold a

method in which a man, if he hearken to reason, may fill his life with acts of obedience to God. Whatever I see to be reason, I will comply with from this consideration, it is what God calls me to. Reason extends to points of morality, with as much evidence as to those of mathematics. It is as evident that God my Maker is to be glorified, and that I am to do as I would be done unto, as it is that three and four make seven; or, that a square is double to a triangle, of equal base and height. May the fear of God for ever preserve me from doing any thing which seems to me unreasonable.

The prodigious learning, with which some men have been enriched; ideas, like the sands on the sea-shore, for the vast variety of them: there have been men of so extensive a genius, that they have been worthy to have a celebration of their obsequies, in as many languages as were those of Peireskius; a collection of which, entitled Panglossia, had in it no fewer than forty languages.

What a character could Vives give of his Budœus? Casaubon reports of Joseph Scaliger, that there is nothing that any man could desire to learn, but he was able to teach. He had read nothing, (and yet what had he not read?) but what he did readily remember. Salmasius gives a report, little short of this, concerning Causaubon. Voetius and Vossius, how do they celebrate the vast erudition of our Usher. Others will or may do as much for theirs. Bochart is rarely mentioned without the epithet of the incomparable. Grotius was no little man: Selden was not much smaller than he: both concluded their lives with testimonies to the preference of

real piety, before all their skill in languages and sciences.

My dear Witsius, lately dead, must for ever live in the catalogue of wonderful men; and Mr. Baxter too. Of these two, and of some others, what Amberacius writes of Zuinger, may be the consummate eulogy; his great learning was small, when put in competition with his piety. Such was he, of whom I am going to repeat what I have heretofore asserted. Had I learning enough to manage a cause of that nature, I should be ready to maintain, that there never was under the cope of heaven a more learned man than the incomparable Alstedius: he has written on every one of the subjects in the whole circle of learning as accurately and as exquisitely as those men who have spent all their lives in cultivating but any one of the subjects. The reason why many of his composures are no more esteemed, is the pleonasm of their worth, and their deserving so much esteem. To hear some filthy and flashy men, with a scornful sneer, talk as if they had sufficiently done his business, by a foolish pun, of all's tedious, is to see the ungrateful and exalted folly of the world; for conciseness is one of his peculiar excellencies: they might more justly call him any thing than tedious.

The early attainments and achievements of some, have been the just admiration of the world. Mr. Baillet has drawn up a curious list of illustrious youths.

When I see such men, and their works, I must for ever look off, and look up to the glorious God, and acknowledge, great God, thou art the Father of these lights. These had nothing but what they

received from thee. And if such perfections may be found in frail and weak men, what are the excellencies of the infinite God, before whom all these men are but as the drop of the bucket, and the light dust of the balance! But when I consider how far the sinful children of men may come to have the chambers of their souls filled with precious things, it leads me to think, what is that Man, who is more than a mere man! that Man, who is the Son of God! O God, the heavens do praise thy wonder! Books which contain most valuable treasures, cannot well be laid out of our hands without such thoughts as these.

But what shall we say when we see the vast performances and capacities of some souls, from which the want of bodily senses would have prohibited all our expectations of any thing that should be considerable. My God, I know that thou canst do every thing; all souls are thine, and thou canst make them do what thou pleasest.

The Jews tell us of a professor in their academy of Sora, who was called Sagi Nahor, or Joseph of great light; he was blind, but it seems he had a soul full of knowledge.

We have had eminent preachers who were blind men, and educated for, and serviceable in the evangelical ministry. Mr. Cheesman, of Eastgarston, was one who lost his eyes by the smallpox, before he was four years old. Thus Mr. Francis Tailor, and Mr. Homer Jackson. But then that they should prove writers too, learned, acute, polite writers!

The books of Mr. John Troughton are valuable. His Lutherus Redivivus could have been wrote by none but a seer, and an eagle-eyed one.

But if many blind men have done learnedly, thou, Mr. William Jameson, hast excelled them all. That miraculous man, a professor of history in the famous university of Glasgow, though blind from his nativity, has published a variety of books, and these in the Latin as well as the English tongue, and full of quotation, criticism, accurate and exquisite explanations on the nicest controversies. When I read such things, I cannot but see the finger of God.

That one faculty of the soul, the memory, how amazing its powers! how stupendous its performances! The account Seneca gives of himself, if half of it be true, is, that "I could repeat two thousand names in the same order in which they were spoken." Of his very dear companion, as he calls Latro Porcius, he affirms, that he retained in his memory all the declamations he had ever spoken, and never had his memory failing him so much as in one single word. Pliny will give us more examples of what the memory of man has done; a Cyrus, who could call all the soldiers in his army by name; a Mithridates, who could speak to twenty-two several nations in their own languages. Such was the memory of Dr. John Rainolds, that he was called a living library, and a third university. Lipsius had all Tacitus exactly in his memory, and Suarez had all Austin. Homer's Iliads have thirty-one thousand six hundred and seventy verses, his Odysses no less; and yet the younger Scaliger committed all Homer to his memory in one and twenty days. The memory of the famous Jewel would perform wonders; he would readily and exactly repeat any thing he had written, after once reading it, and would have

done it if the auditors had been shouting or fighting, and given him the greatest occasions of confusions; even scores of barbarous words, after once reading, he would repeat forwards and backwards, without hesitation. Zuinger mentions many strange examples of a strong memory, among which that of Christopher Longolius is very memorable; scarce any length of time was able to dislodge any thing he had once lodged in his memory. But then how unaccountable the instances of a Lœsa Memoria, reported by Zuinger, Forestus, Schenkius, and others, especially when an apoplexy has left a man memory enough to write volumes, but unable to read a syllable. The various inclinations of the soul are a most admirable wise providence of our God, that the business of the world may be all transacted, and with satisfaction.

Though Solomon declares truly, that much study is a weariness to the flesh, yet with what assiduity do many apply themselves to it, and how delightfully! There have been other hard students besides Cato, of whom Tully says, "He had so great a desire for reading, that he could not be satisfied."

The Jews have done well to place this among their Beracoth; God inclines every one to be contented with his own employment. The blessed God is to be acknowledged in it. There is an instance which Dr. Edwards has pitched upon: Would a gentleman brought up a scholar, and one very nice, neat, and curious, visit sick persons whenever they call him, and leave his own bed to visit them in theirs, and enter into rooms that are filled with the most ungrateful steam and stench?

One would think this were a degradation to the velvet cap and scarlet robe; to go in silk and plush to the most squalid and nasty chambers, looks a little strange; to suck in the air of a room which the breath of the diseased has infected, for this to be done by persons of an honourable character, and for them to undergo patiently and cheerfully more servile things than what are undergone in the basest and most servile callings. But, "behold, I have created the smith, who blows the coals in the fire! so saith our God: and he is to be seen in the disposition to profess every honest trade for necessary uses. When I behold any man cheerfully following the business of his calling, I would upon the invitation say, Glorious God, it is well that thou hast so disposed the mind of this my neighbour!"

They who have written of the diseases of mechanics, have mentioned no case more deplorable than this, for a man to be sick of his calling.

Our great God is to be seen, confessed, adored, in that admirable variety of matters which the invention of man has reached to! and the admirable sagacity that prosecutes them! When such inventive wits as Helmont and Wallis have taught the deaf and the dumb to read and speak, methinks I have seen that sagacity notably exemplified.

"Glorious God, my soul with all possible prostration before thee receives thy faithful sayings, wherein thou hast instructed me: Every good gift comes down from the Father of lights, and the Lord giveth wisdom! not only of the four children that had it, but of all that have ever had any thing of it, it must be owned God gave them *knowledge* and skill in all learning and wisdom:

if a Bazaleel have it, O Spirit of God, thou art He who givest him knowledge in all manner of workmanship."

But then there is another thing wherein the superintendence of the glorious Creator and Governor of the world is most conspicuous; and that is, the progress which the invention of man has made: things of greater use were sooner invented, things of a lesser use later, every thing in the time wherein our great God has had his excellent purposes to be served with it; things equally plain with such as have been formerly discovered, and as much desired, have been locked up from human understanding, till the God, in whose hand are our times, is pleased wisely to make them understood by the children of men. It is not from your fortuitous concourse of atoms, ye foolish epicureans! Why must printing be withheld from the service of mankind till the year 1450, when the first-born of printed books was by the hand of Laurence Kofter midwifed into the world, and the skill immediately improved by Faust and Schoeffer? Why must mankind have no telescopes till the year 1609, when one whom Syrtutus would suspect almost an angel in the shape of a Dutchman, instructed Lippersein at Middleburgh to proceed on them? To mention a subject which my Christian philosopher has very much lived upon, what is the anatomy of Mundinus, if compared to our modern? (though Cardan, and other learned men, have so much cried it up with their eulogies and commentaries.) Baglivi says truly, it is as far short of it as a flea is of an elephant. We shall pass to another instance: The Romans had not so much as a sun-dial till the second Punic

war, and when they had one, they had no more than that one, in a forum, above a hundred years, though Pliny says it never went right in all this time. King Alfred had no better shift than this for measuring his hours, the burning of a candle, marked into twelve parts, for which a lanthorn was needful to secure it from the winds of the windows, for glazing was not yet in fashion. Dr. Grew observes, the first conceit which tended to a watch, was a draw-well; first, people found the drawing of water with a hand-cord and a pitcher troublesome, so they thought of a draught-wheel; by and by they conceived such a movement applicable to a spit, if the motion of the weight could be made slow enough, this was done by adding more wheels and a flier, which made a jack: by and by men began to see, that if the motion were yet slower, it would serve to measure time also, then instead of a flier they put a balance, and thus made a clock; this being so useful, men considered how it might be made portable, by something answerable to a weight, and so instead of that they put the spring and the fuse-wheel, which make a watch. Here is the pedigree of the noble engine. But to what an astonishing perfection is clock-work and watch-work now arrived! We will hardly allow a gentleman of such antiquity as Boethius to be the inventor of the clock-work, that hath been so mightily improved; no, Regiomontanus, thou shalt have the honour of being the instrument employed by God for the rare invention, not more than between two and three hundred years ago. The curious performances of clock-work cannot be related without our finding a surprise of pleasure in the relations; how many

motions produced! how many designs answered! The gentleman who writes the Artificial Clock-maker, has with his calculations made a provision for a marvellous variety of them. What Heylin in his Cosmography reports of the clock at Lunden in Denmark, what Gaffarel in his unheard-of curiosities reports that he himself saw in a clock at Ligorn, and the clock which every day diverts the spectators at Harlem, are notable instances among many others. The repeating-clocks are now common on thousands of tables, but how curious! At length Mr. Huygens has invented the way of applying pendulums to watch-work. If Galilæo entertained a thought of such a thing, yet he never brought it to perfection. We must not let Mr. Huygens be robbed of his claim, either by Becher, or the Academy del Cimento. The first that was made in England was in the year 1662. The uses of these pendulum-watches cannot be sufficiently celebrated. But useful indeed will be these measurers of time, if they teach and help us to be the more wise redeemers of it.

It was thought, that he, who when patents for monopolies were granting in France, begged for one to demand a shilling from every man that wore a watch, but had no care how he spent his time, asked for what would have afforded a revenue too rich for a subject!

If the mathematics, which have in the two last centuries had such wonderful improvements, do for two hundred years more improve in proportion to the former, who can tell what mankind may come to!

The union between the soul and the body is *alto*gether inexplicable, the soul not having any

surface to touch the body, and the body not having any sentiment as the soul. The union of the soul and body does consist, as Monsieur Tauvry expresses it, in the conformity of our thoughts to our corporeal actions; but, says he, for the explication of this conformity, we must have recourse to a superior power. Truly, sirs, do what you can, you must quickly come to that!

Our nervous parts are very sensible. Objects affect our senses, and make impressions on them; the senses receiving such impressions, the modifications of the organs produced by them terminate in the brain; if they do not so, the soul is unconcerned in them; but there is a law given to the soul by the glorious God, who forms the spirit of man within him, that in their doing so there shall be such and such thoughts produced in the soul.

"O my soul, what a wonderous being art thou! how capable of astonishing improvements! how worthy to have all possible endeavours used for thy recovery from the depravations which thy fall from God has brought upon thee! how worthy to be kept with all diligence from every thing that will bring any more wounds upon thee! what reason is there that thou shouldst be filled with the love of God, and acted by the faith of thy only Saviour! and if the image of the glorious God, which has been impaired by Satanic impressions on thee, be revived and restored in thee, what marvellous, and even eternal felicities, art thou sure of arriving at!"

But, O man, wilt thou stop here, and know nothing above thyself? Among the ancient Jews there was a sort of natural philosophers, so called *from their inquiring after natural causes*; perhaps

the apostle may mean these, when he says, 1 Cor. i, 20. Where is the inquirer of this world? Jerome's version favours it. Now of these persons it is reported, that they denied the existence of superior intelligences; the Christian philosopher will not be guilty of such a stupidity.

We are now soaring into the invisible world, a world of intellectual beings, but invisible to such eyes as ours. I do here in the first place most religiously affirm, that even my senses have been convinced of such a world, by as clear, plain, full proofs as ever any man's have had of what is most obvious in the sensible world; proofs which I am ready to offer in the most convenient season. But then, how glorious art thou, O God, in thy innumerable company of the holy angels, and in thy government over those also that have made themselves evil ones! All the wonders we have hitherto seen in the visible creation, what are they, compared to those that are out of sight, those that are found among the angels that excel in powers, the hosts of the infinite God, the ministers which do His pleasure!

There is a scale of nature, wherein we pass regularly and proportionably from a stone to a man, the faculties of the creatures in their various classes growing still brighter and brighter, and more capacious till we arrive to those noble ones which are found in the soul of man; and yet man is, as one well expresses it, but the equator of the universe.

It is a just view which Dr. Grew had of the world, when he came to this determination: "as *there* are several orders of animated bodies before we come to intellect, so it must needs be that

there are several orders of embodied intellect before we come to pure mind."

It is likely that the transition from human to perfect mind is made by a gradual ascent; there may be angels whose faculties may be as much superior to ours, as ours are to those of a snail or a worm.

By and by we may arrive at minds divested of all body, excellent minds, which may enjoy the knowledge of things by a more immediate intuition, as well as without any inclination to any moral evil.

The highest perfection that any created mind can arise to, is that in the soul of our admirable Saviour, which is indeed embodied; but it is the soul of the Man who is personally united to the Son of God.

Anon we see an infinite God; but canst thou by searching find out God? Canst thou find out the Almighty unto perfection?

It is a good thought, and well expressed by a holy writer on the knowledge of God from the works of creation. "It is true there are some footsteps of a Deity in all the works of nature, but we should ascend by these footsteps, as by a footstool, to the God of the world, as Solomon by several steps ascended to his throne, and by the scale of nature ascend to the God of nature."

This is what we shall now, though in a more summary way, a little more distinctly proceed to.

No dominion over the creatures can be more acceptably, more delightfully exercised with me than this; for me to employ them as often as I please in leading me to God, and so in serving *that which I* propose as the chief end for which I

live, and move, and have my being; which is, to glorify God, and acknowledge him. When the creatures were brought to our protoplast, to see what he would call them, he did not exercise a more desirable dominion over them, in giving what name he pleased to each of them, than I shall do in having them all brought to me, that I may read the name of God, so far as it is to be seen in them, and be assisted in my acknowledgments to him.

Hear now the conclusion of the matter. To enkindle the dispositions and the resolutions of piety in my brethren, is the intention of all my essays, and must be the conclusion of them.

Atheism is now for ever chased and hissed out of the world, every thing in the world concurs to a sentence of banishment upon it. Fly, thou monster, and hide, and let not the darkest recesses of Africa itself be able to cherish thee; never dare to shew thyself in a world where every thing stands ready to overwhelm thee! a Being that must be superior to matter, even the Creator and Governor of all matter, is every where so conspicuous, that there can be nothing more monstrous than to deny the God that is above. No system of atheism has ever yet been offered among the children of men, but what abounds with such inconsistences, that a man must ridiculously believe nothing certain before he can imagine them; it must be a system of things which cannot stand together! a bundle of contradictions to themselves, and to all common sense. I doubt it has been an inconsiderate thing to pay so much of a compliment to atheism, as to bestow solemn treatises full of learned arguments for a refutation of a delirious phrenzy, which ought

rather to be put out of countenance with the most contemptuous indignation. And I fear such writers as have been at the pains to put the objections of atheism into the most plausible terms, that they may have the honour of laying a devil when they have raised him, have therein done too unadvisedly. However, to so much notice of the raving atheist we may condescend while we go along, as to tell him, that for a man to question the being of a God, who requires from us a homage of affection, and obedience to himself, and a perpetual concern for the welfare of the human society, for which He has in our formation evidently suited us, would be an exalted folly, which undergoes especially two condemnations; it is first condemned by this, that every part of the universe is continually pouring in something to confute it; there is not a corner of the whole world but what supplies a stone towards the infliction of such a death upon the blasphemy as justly belongs to it: and it has also this condemning of it, that men would soon become cannibals to one another by embracing it; men being utterly destitute of any principle to keep them honest in the dark, there would be no integrity left in the world, but they would be as the fishes of the sea to one another, and worse than the creeping things, that have no ruler over them. Indeed from every thing in the world there is this voice more audible than the loudest thunder to us; God hath spoken, and these two things have I heard! First, believe and adore a glorious God, who has made all these things, and know thou that He will bring thee into judgment! And then be careful to do nothing but what shall be for the

good of the community of which the glorious God has made thee a member. Were what God hath spoken duly regarded, and were these two things duly complied with, the world would be soon revived into a desirable garden of God, and mankind would be in very comfortable circumstances; till then the world continues in a wretched condition, full of doleful creatures, with wild beasts crying in its desolate houses, dragons in its most pleasant palaces. And now declare, O every thing that is reasonable, declare and pronounce upon it whether it be possible that maxims absolutely necessary to the subsistence and happiness of mankind, can be falsities? There is no possibility for this, that cheats and lies must be so necessary, that the ends which alone are worthy of a glorious God, cannot be attained without having them imposed upon us!

Having despatched the atheist, with bestowing on him not many thoughts, yet more than could be deserved by such an idiot; I will proceed now to propose two general strokes of piety which will appear to a Christian philosopher as unexceptionable as any proposals that ever were made to him.

First, the works of the glorious God exhibited to our view, most certainly bespeak, and should excite our acknowledgments of his glories appearing in them. The great God is infinitely gratified in beholding the displays of his own infinite power, wisdom, and goodness, in the works which he has made; but it is also a most acceptable gratification to him, when such of his works as are the rational beholders of themselves, and of the rest, shall with devout minds acknowledge his perfections, which they see shining there. Never

does one endued with reason do any thing more evidently reasonable, than when he makes every thing that occurs to him in the vast fabric of the world, an incentive to religion. What can any man living object against the piety of a mind awakened by the sight of God in his works, to such thoughts as these: Verily, there is a glorious God! Verily, the God who does these things is worthy to be feared, loved, and relied on! Verily all possible obedience is due to such a God; and most abominable, most inexcusable is the wickedness of all rebellion against him. A mind impressed with such thoughts as these, is holy, a temple filled with the glory of God. There is nothing but what will afford an occasion for the thoughts; the oftener a man improves the occasion, the more does he glorify God, and answer the chief end of man; and why should he not seek occasion for it, by visiting for this purpose the several classes of the creatures, as he may have opportunity, for so generous an exercise? But since the horrid evil of sin is to be inferred from this; it is a rebellion against the laws of the glorious God, who is the Maker and the Ruler of all worlds; and it is a disturbance of the good order wherein the glorious Maker and Ruler of all things has placed them all; how much ought a quickened horror of sin to accompany this contemplation, and produce this most agreeable resolution, my God, I will for ever fear to offend thy glorious Majesty. Nor is this all the improvement which we are to make of what we see in the works of God; in improving them, we are to accept the rebuke which they give to our presumption, in pretending to criticise upon the dark

things which occur in the dispensations of Providence; there is not any one of all the creatures but what has those fine things in the texture of it, which have never yet been reached by our researches, and we are as much at a loss about the intent, as about the texture of them; as yet we know not what the glorious God intends in his forming of those creatures, nor what he has to do in them; he therein proclaims this expectation, Surely they will fear me, and receive instruction. And the point wherein we are now instructed is this: "What! shall I be so vain as to be dissatisfied because I do not understand what is done by the glorious God in the works of his providence!" O my soul, hast thou not known, hast thou not heard, concerning the everlasting God, the Lord, the Creator of the ends of the earth, that there is no searching of his understanding?

And then, secondly, the Christ of God must not be forgotten, who is the Lord of all. I am not ashamed of the Gospel of Christ, of which I will affirm constantly, that if the philosopher do not call it in, he paganizes, and leaves the finest and brightest part of his work unfinished. Let Colerus persuade us if he can, that in the time of John Frederic, the elector of Saxony, there was dug up a stone, on which there was a representation of our crucified Saviour; but I cannot forbear saying, there is not a stone any where which would not look black upon me, and speak my condemnation, if my philosophy should be so vain as to make me lay aside my thoughts of my enthroned Saviour. Let Lambecius, if he please, employ his learning upon the name of our Saviour Christ, found in letters naturally engraven

at the bottom of a large agate cup, which is to be seen among the emperor's curiosities; but I will assert, that a glorious Christ is more to be considered in the works of nature than the philosopher is generally aware of; and my Christian philosopher has not fully done his part, till He, who is the first-born of every creature come into consideration with him. Alsted mentions a siclus judœo-christianus, which had on one side the name Jesus, with the face of our Saviour; and on the other, the words that signify, the King Messiah comes with peace, and God becomes a man: and Leusden says he had a couple of these coins in his possession. I have nothing to say on the behalf of the zeal in those christianized Jews, who probably were the authors of these coins, a zeal that boiled into so needless an expression of homage, that indeed cannot be too much expressed in the instituted ways of it to a Redeemer, whose kingdom is not of this world: but this I will say, all the creatures in this world are part of his kingdom; there are no creatures but what are his medals, on every one of them the name of Jesus is to be found inscribed. Celebrate, O Danhaver, thy granatilla, the Peruvian plant, on which a strong imagination finds a representation of the instruments employed in the sufferings of our Saviour, and especially the bloody sweat of his agonies. But I will, with the exercise of the most solid reason, by every part of the world, as well as the vegetables, be led to my Saviour.

A view of the creation is to be taken, with suitable acknowledgments of the glorious Christ, in whom the eternal Son of God has personally *united himself* to one of his creatures, and be-

comes, on his account, propitious to all the rest; our piety indeed will not be christianity if He be forgottten.

This is he of whom we are instructed, Col. i, 16, 17, All things were created by him, and for him; and he is before all things, and by him all things consist. And certainly he that as a father produces a son, but as an artist only a house, has a value for the son which he has not for the house; yea, we may say, if God had not first, and from eternity, been a Father to our Saviour, he would never have exerted himself, as an artist in that fabric, which he has built by the might of his power, and for the honour of his Majesty.

The great Sir Francis Bacon has a notable passage in his confession of faith: I believe that God is so holy, as that it is impossible for him to be pleased in any creature, though the work of his own hands, without beholding the same in the face of a Mediator; without which it was impossible for him to have descended to any work of creation, but he should have enjoyed the blessed and individual society of three persons in the Godhead for ever; but out of his eternal and infinite goodness and love, purposing to become a creature, and communicate with his creatures, he ordained in his eternal counsel, that one person of the Godhead should be united to one nature, and to one particular of his creatures; that so in the person of the Mediator the true ladder might be fixed, whereby God might descend to his creatures, and his creatures ascend to him.

It was a high flight of Origen, who urges, that our High-Priest, having tasted death for all, is to be extended even to the very stars, which would

otherwise have been impure in the sight of God; and thus are all things restored to the kingdom of the Father. The apostle Paul, in a famous passage to the Colossians, (i, 19, 20,) may seem highly to favour this flight. One says upon it, "If this be so, we need not break the glasses of Galilœo, the spots may be washed out of the sun, and total nature sanctified to God that made it."

Yea, the sacred Scriptures plainly and often invite us to a conception, which Dr. Goodwin has chosen to deliver in such terms as these: "The Son of God personally and actually existing as the Son of God with God, before the world or any creature was made, He undertaking and covenanting with God to become a Man, yea, that Man which he hath now taken up into one person with himself, as well for this end, as for other ends more glorious; God did, in the fore-knowledge of that, and in the assurance of that covenant of his, proceed to the creating of all things which he hath made; and without the intuition of this, or having this in his eye, he would not have made any thing which he hath made."

O Christian, lift up now thine eyes, and look from the place where thou art to all points of the compass, and concerning whatever thou seest, allow that all these things were formed for the sake of that glorious One, who is now God manifest in the flesh of our Jesus; it is on his account that the eternal Godhead has the delight in all these things which preserves them in their being, and grants them the help by which they continue to this day.

But were they not all made by the hand, as well as for the sake of that glorious One? They were

verily so. O my Jesus, it was that Son of God who now dwells in thee, in and by whom the Godhead exerted the power, which could be exerted by none but an all-powerful God, in the creating of the world. He is that Word of God by whom all things were made, and without whom was not any thing made that was made.

This is not all that we have to think upon; we see an incomparable wisdom of God in his creatures; one cannot but presently infer, what an incomprehensible wisdom then in the methods and affairs of that redemption, of which the glorious God has laid the plan in our Jesus! Things which the angels desire to look into. But, O evangelized mind, go on, mount up, soar higher, think at this rate; the infinite Wisdom which formed all these things is peculiarly seated in the Son of God; He is that reflexive Wisdom of the eternal Father, and that Image of the invisible God, by whom all things were created; in Him there is, after a peculiar manner, the original idea and archetype of every thing that offers the infinite wisdom of God to our admiration. Wherever we see the wisdom of God admirably shining before us, we are invited to such a thought as this; this glory is originally found in thee, O our Immanuel! But then it is impossible to stop without adding, How glorious, how wonderous, how lovely art thou, O our Saviour!

Nor may we lay aside a grateful sense of this, that as the Son of God is the upholder of all things in all worlds, thus, that it is owing to his potent intercession that the sin of man has made no more havoc on this our world. This our world has *been by* the sin of man so perverted from the true

ends of it, and rendered full of such loathsome and hateful regions, that the revenges of God would have long since rendered it as a fiery oven, if our blessed Jesus had not interceded for it: O my Saviour, what would have become of me, and of all that comforts me, if thy intercession had not preserved us!

We will add one thing more. Though the one God, in his three substances, be the Governor as well as the Creator of the world, and so the Son of God ever had what we call the natural government of the world, yet upon the fall of mankind a mediatory kingdom becomes expedient, that guilty man may be brought to God; and the singular honour of this mediatory kingdom is more immediately and most agreeably assigned to the Son of God, who assumes the Man Jesus in his own person, and has all power in heaven and earth given to him; all things are now commanded and ordered by the Son of God in the Man upon the throne, and this to the glory of the Father, by whom the mediatory kingdom is erected, and so conferred. This peculiar kingdom thus managed by the Son of God in our Jesus, will cease when the illustrious ends of it are all accomplished, and then the Son of God no longer having such a distinct kingdom of his own, shall return to those eternal circumstances, in which he shall reign with the Father and the Holy Spirit, one God, blessed for ever. In the mean time, what creatures can we behold without some such doxology as this; O Son of God, incarnate and enthroned in my Jesus, this is part of thy dominion! What a great King art thou, and what a name hast thou above every name, and how vastly extended is thy

dominion! Dominion and fear is with thee, and there is no number of thine armies! All the inhabitants of the earth, and their most puissant emperors are to be reputed as nothing before thee!

But then at last I am losing myself in such thoughts as these: Who can tell to what uses our Saviour will put all these creatures at the restitution of all things, when He comes to rescue them from the vanity which as yet captivates and incumbers them! and his raised people in the new heavens will visit a new earth, which they shall find flourishing in paradisaic regularities? Lord, what thou meanest in them, I know not now, but I shall know hereafter! I go on, who can tell how sweetly our Saviour may feast his chosen people in the future state, with exhibitions of all these creatures, in their various natures, and their curious beauties? Lord, I hope for an eternally progressive knowledge, from the Lamb of God successively leading me to the fountains of it!

I recover out of my more conjectural prognostications, with resolving what may at present yield to a serious mind a satisfaction, to which this world knows none superior: when in a way of occasional reflection I employ the creatures as my teachers, I will by the truths wherein those ready monitors instruct me, be led to my glorious Jesus; I will consider the truths as they are in Jesus, and count my ascetics deficient, till I have some thoughts of Him and of his glories awakened in me. To conclude, it is a good passage which a little treatise entitled, The Book of Nature, breaks off with, and I might make it my conclusion: "If we mind heaven whilst we live here upon earth, this earth *will serve* to conduct us to heaven, through the

merits and mediation of the Son of God, who was made the Son of man, and came thence on purpose into this lower world to convey us up thither."

I will finish with a speculation, which the most valuable Dr. Cheyne has a little more largely prosecuted and cultivated.

All intelligent compound beings have their whole entertainment in these three principles, the desire, the object, and the sensation arising from the congruity between them; this analogy is preserved full and clear through the spiritual world, yea, and through the material also; so universal and perpetual an analogy can arise from nothing but its pattern and archetype in the infinite God, our maker; and could we carry it up to the source of it, we should find the Trinity of persons in the eternal Godhead admirably exhibited to us. In the Godhead we may first apprehend a desire, an infinitely active, ardent, powerful thought, proposing satisfaction; let this represent God the Father; but it is not possible for any object but God himself to satisfy himself, and fill his desire of happiness; therefore He himself reflected in upon himself, and contemplating his own infinite perfections, even the brightness of his glory, and the express image of his person, must answer this glorious intention; and this may represent to us God the Son. Upon this contemplation, wherein God himself does behold, and possess, and enjoy himself, there cannot but arise a love, a joy, an acquiescence of God himself within himself, and worthy of a God; this may shadow out to us the third and the last of the principles in this mysterious ternary, that is to say, the Holy Spirit. Though these three relations of the Godhead in itself, when

derived analogically down to creatures, may appear but modifications of a real subsistence, yet in the supreme infinitude of the Divine nature, they must be infinitely real and living principles. Those which are but relations, when transferred to created beings, are glorious realities in the infinite God. And in this view of the Holy Trinity, low as it is, it is impossible the Son should be without the Father, or the Father without the Son, or both without the Holy Spirit; it is impossible the Son should not be necessarily and eternally begotten of the Father, or that the Holy Spirit should not necessarily and eternally proceed both from Him and from the Son. Thus from what occurs throughout the whole creation, reason forms an imperfect idea of this incomprehensible mystery. But it is time to stop here, and indeed how can we go any further.

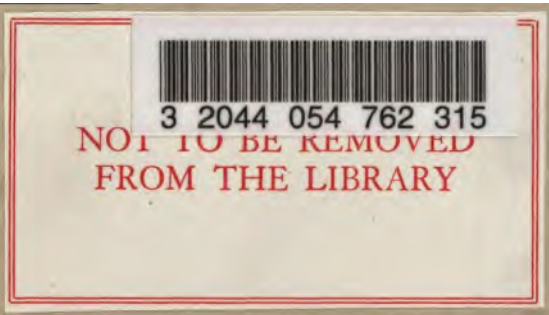
THE END.

PRIDEAUX' CONNEXION.

As the proprietor of the Middlesex Book Store is engeged in publishing an edition of this valuable work, he would inform the public that his edition will be printed (on a new and elegant type, cast expressly for the purpose, by Messrs. E. White & Co. New York,) from the 16th London edition: edited by Mr. ADAM CLARK, who has made several important corrections and improvements in the Maps which accompany the work.

The "Christian Scholar" would be gratified as well as the publisher by his subscription to this edition of Prideaux' Connexion, as it will be done in a superior style to any edition before published, which has fallen under the observation of the American editor.

Charlestown, August, 1815.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